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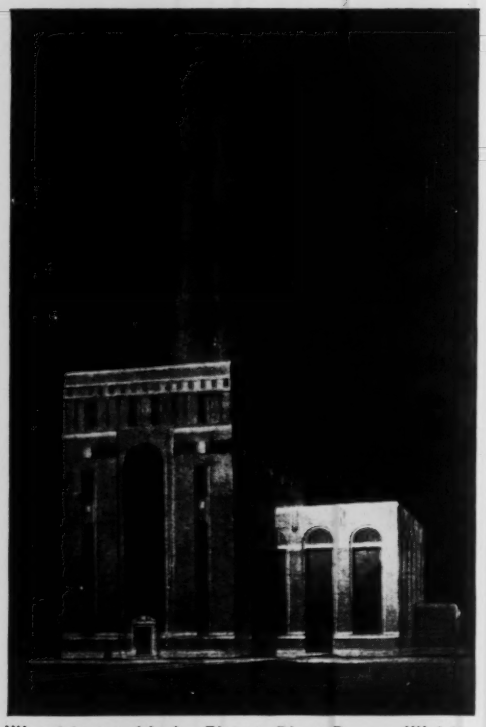
# MECHANICAL ENGINEERING

C. P. R. 8000-Type
Multiple-Pressure Locomotive

October 1931

# WALSH-WEIDNER BOILERS SERVE NEW STEAM PLANT OF WEST VIRGINIA HYDRO-ELECTRIC



West Virginia Hydro-Electric Plant, Boncar, W. Va.
Ford, Bacon & Davis, Inc., Engineers

At the Boncar Station of the West Virginia Hydro-Electric Company, two Combustion Engineering steam generating units were recently installed. These units each comprise a Walsh-Weidner Sectional-Header Boiler of the single-pass type, Lopulco Pulverized-Fuel Tangential Burners and C-E Water-Cooled Furnace.

Each boiler is 30 sections wide, 42 tubes high, and contains 31,825 sq. ft. of heating surface; working pressure, 488 lb. per sq. in.; total steam temperature, 760 deg. fahr. The maximum capacity of each unit is 325,000 lb. of steam per hour.

The fact that each of these units is to supply steam for a 30,000 kw. generator is an indication of the absolute confidence placed in the reliability of C-E steam generating units.

• • •

A Condensed Catalogue, which briefly describes the Walsh-Weidner boiler and all other Combustion Engineering products, will be sent to you upon request.

**COMBUSTION ENGINEERING CORPORATION**

**200 MADISON AVENUE • NEW YORK**

Looking up into the Walsh-Weidner Boiler from the bottom of the furnace.

# Mechanical Engineering

The Monthly Journal Published by

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# What It's All About

THIS MONTH'S COVER shows the new C.P.R. locomotive of the multiple-pressure type. As explained in paper RR-51-4 in the 1929 Transactions of the A.S.M.E. Railroad Division, steam is generated at three pressures. Heating steam is formed at 1350 to 1700 lb. in a closed circuit, and generates, through surfaces not exposed to the fire, working steam at 850 lb. for the high-pressure cylinders. In addition steam at 250 lb. is formed by means of exhaust gases for use in the low-pressure cylinders.

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SUCH a radical change in locomotive design is typical of the rapid advance of technology, which brings with it new problems necessitating constant study and an alert speculation as to implications.

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FOR example, in this month's "Survey" is a description of a liquid engine recently announced by J. F. J. Malone which uses heat as a source of energy, and water, alternately expanded and compressed, as a working medium. The engine involves the regenerative principle proposed for the hot-air engine.

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WHAT the future holds for this engine no one can predict, but the importance of the heat-transfer element is unquestioned. This calls attention to a new heat-transfer medium described in a paper by John J. Grebe on "Diphenyloxide for Preheating Air." This high-boiling-point organic compound, whose thermal properties are tabulated in the paper, is used to abstract heat from chimney gases and deliver it to the air used in combustion.

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UNLIKE water and air, diphenyloxide is the result of man's ability to manufacture useful chemical substances. Without machinery, chemistry, and engineering, such process industries would not be commercially important. The fundamental machinery of these industries is of major interest to mechanical engineers. Recently the A.S.M.E. Process Industries Committee contributed a paper by E. M. James on "The Continuous Centrifugal," published in this issue, at a joint meeting with the American Institute of Chemical Engineers, thus inaugurating a new program of mechanical-engineering development.

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ANOTHER noteworthy advance is the improvement of fusion welding to a point where it is permissible under the revised rules of the A.S.M.E. boiler code, published in the June, 1931, issue of MECHANICAL ENGINEERING. Class 1 pressure vessels, which are those without restriction as to use or service, must be tested in several ways, among which is X-ray examination. This gives especial interest to this month's paper by Herbert R. Isenburger on "Radiographic Inspection of Metals."

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A STUDY of the thermodynamics of high-pressure water, long overdue, is contributed this month by Julian C. Smallwood.

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TECHNOLOGICAL improvements bring unexpected problems. Some are trivial, others are of the utmost importance to society. Consider, for example, machining finishes. Years ago the machinist used his own judgment in finishing a piece where today he cannot do so. For example, he cannot judge whether a rough or a high finish is necessary. In discussing the "Standardization of Machining Finishes" this month, R. C. Deale puts this responsibility up to the designer, and proposes a system of notation for shop drawings to indicate whether a high, commercial, or rough finish is required.

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TURNING to another type of problem, no one will deny the importance of accident prevention, discussed this month by David S. Anderson in an article entitled "Accident Prevention Through Safety Engineering." And the "Survey" deals with still another, typical of the machine age—noise.

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MOST baffling of all problems that involve the engineer today is the relation between technological improvements and the present economic crisis. Engineers as managers have developed an interest in unemployment. This month James W. Hook, in an article on "Industry's Obligation to the Unemployed," describes a plan, actually in practice, for determining who are the stable workers in a plant, and for obtaining data as a basis for a reserve to tide them over times of depression.

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A CLIMAX in a list of problems arising out of advances in technology is reached in their cultural and metaphysical implications. These are discussed this month in an address by R. Plank on "Engineering and Modern Culture." It should receive careful reading and thorough study.

MECHANICAL ENGINEERING

Volume 53 October, 1931 No. 10

# Industry's Obligation to the Unemployed

## Describing a Plan, Actually in Practice, for Determining Who Are the Stable Workers in a Plant, and for Obtaining Actuarial Data as a Basis for a Reserve to Tide Them Over Times of Depression

By JAMES W. HOOK,[1] NEW HAVEN, CONN.

THE TREND of thought in this country growing out of the depression indicates, beyond much question, that we are headed toward social experiments in connection with unemployment that may have very far-reaching effects. No one will deny that something must be done about the perplexing problem, but just what it shall be and what elements in our society shall pay the cost, are questions requiring the best and most unselfish thought that we are able to give.

It is a basic principle of democratic economy that the whole population should be provided with the necessities of life at all times. No one should be allowed to starve or freeze as long as the wherewithal to keep him from doing so exists and is available. Democracy does not, however, guarantee equal division of procurable goods and services among its subjects, but rather attempts to establish conditions which afford equal opportunity for all to acquire these things in proportion to the skill and wisdom and effort which, under the impetus of normal inclination, they put forward to obtain them. Under such a plan it is natural to expect that some persons, because of limitations within themselves or of circumstances wholly beyond their control, will, at times, be in want of essential things and without means of obtaining them. When this happens, society comes forward with a helping hand and provides, in one way or another, the assistance that is needed.

Society has learned much from this experience. It is gradually beginning to realize that saving a person from starving or freezing is not enough. If such action, humane as it may be at the moment, destroys the person's self-respect and instils in him a permanent-failure complex, it has made of him a continuing charge upon society, and in some cases, and all too often, a menace as well. Society, therefore, is seeking better ways of rendering assistance to its needy, placing the burden where it belongs and in a manner that will not create unfavorable reactions that in themselves may offset all of the good done.

There is, probably, no single social phenomenon that has a more destructive effect upon the mental attitude and morals of its victims than that which causes people to be thrown out of employment. It wrecks plans, weakens ideals, checks ambitions, and arouses bitterness and criticism that go far to undermine our social system. Every man and woman has a deep-rooted feeling that he or she has the right to earn a living by legitimate toil. Willingness to toil presupposes jobs. When jobs are not to be had, society is accused, and, regardless of logic or argument, must accept the responsibility.

Who or what is to blame for the conditions that cause unemployment? If we are speaking of seasonal unemployment, the answer is not so difficult to find. If we are referring to that unemployment which is caused by improved machinery and improved methods, the answer becomes slightly more complicated. If we are speaking of cyclical depressions and the unemployment

**RECENTLY our payroll department calculated what would have been necessary in the way of reserves to have maintained the wages of our stable group of employees in office and shop at 80 per cent of normal for those with dependents and 60 per cent of normal for those without for 52 weeks of short-time work.**

**It was quite amazing to us to find that such a reserve would have amounted to but three-quarters of one per cent of the payroll for the years 1923–1929, inclusive. During that same period our company provided in other reserves an equivalent of 13½ per cent of the same group of payrolls. If our experience is at all representative, it would seem that industry can well afford to tide its stable group of employees over extended periods of depressed business. It is an obligation, I believe, that industry should voluntarily assume.—James W. Hook.**

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[1] President, The Geometric Tool Co. Member of The President's Emergency Committee for Employment, Chairman of The Connecticut Unemployment Commission, Chairman of the Industrial Committee of the New England Council and member of the Council. Mem. A.S.M.E.

An address delivered at the First Conference on Management Problems of the Smaller Industries, Silver Bay on Lake George, N. Y., August 10 to 15, 1931.

that accompanies them, then, I believe, we are all in a complete fog as to who or what causes them.

We do know, however, that when great unemployment crises come, society as a whole must take steps at once to mitigate the distress that follows. Regardless of causes, effects are realities that put a definite obligation upon society. If it could be said that the obligation bears alike upon all classes, it would be comparatively easy to say who should pay the cost of discharging it, but, unfortunately, the problem is not quite so simple as that. Unemployment is a by-product of an attitude of mind of the people which curtails their willingness to buy basic commodities and manufactured goods. What brings this attitude about is not known. It is a mass reaction of the people that manifests itself often and in many and diverse ways. Adroit politicians detect it in advance of elections. Speakers feel it in the debating hall. The sensitive stock market reacts to it with almost uncanny precision. To say that its causation is something to which every class of society contributes equally would be going too far. More properly it is a product of leadership which is perhaps too apparent when the going is pleasant and good, and certainly too much in concealment when the going is rough.

For this and other reasons it would appear that both the causes of unemployment and the responsibility for mitigating the distress that accompanies it bear unequally upon different classes of society. As a part of society and as its greatest employer, industry, of course, will not deny that it is partly responsible. It will not admit the whole responsibility, however, nor will it stand by, serene and complacent, while the attempt is made, as it surely will be, to thrust the whole burden upon it.

## What Is Industry?

What, then, is the responsibility of industry to the unemployed? Before attempting to answer this question we must know precisely what we mean by "industry." No word in the English language, perhaps, has such a faculty for creating misconceptions in the human mind. To one it means only manufacturing; to another it means all human activity. To one it means bricks and mortar and whirring machinery; to another it means capital and management. Webster's Dictionary says it means any one of six things, ranging from individual skill and ingenuity to a European variety of gooseberry.

We shall use the word as meaning the sum total of individuals, partnerships, and corporations that supply human beings with gainful employment. This includes employers in agriculture, trade, transportation, manufacturing, mining, banking, the professions, and government. It is probably not quite proper to use the word in this sense. Strictly speaking, it would be better, perhaps, to use the word "employers." But that word always implies personality, whereas industry in the sense above described includes the indirect impersonal as well as personal bodies for which and for whom men and women labor for hire. However, both words will be used hereafter synonymously.

## Employers and Employees

With this definition in mind we can think of all human society as being divided into two general classes. In one class is the employer who employs people to work for him. He may be, and probably is, an employed person himself, working for the same agency that he is employing for. He may be an employer in another sense, too, by reason of his stock holdings in other corporations. He is the consumer of manufactured goods and indirectly increases employment by the purchases he makes. If, for any reason, his ability or desire to purchase declines, he unconsciously, but, nevertheless, truly, adds his bit to the causes for unemployment. In the other class is the employee who works for others and receives in return a salary or wage. He may be the president of a great corporation, a skilled or unskilled worker in a factory, a farm hand in the West or South, a worker on a railroad, or a truck driver for a department store. He represents the gainfully employed (approximately 40 per cent of the population of the country) and provides for 98 per cent. He owns a large share of the private property and corporate wealth in the country, and by virtue of that fact is an employer. When his buying power is curtailed even a slight amount, production slows down, and available work to be done declines.

It would be possible to carry this somewhat academic analysis along much further to show how intertwined those two classes of society are and how dependent one is upon the other, but time will not permit. Yet, if we stop precisely at the point reached by the analysis, we shall overlook one very important thing. It is true that the gainfully employed (constituting 40 per cent of the population) owns a very large part of the wealth of the country. It is only necessary to add that 64 per cent of that wealth is owned by 10 per cent of the class.[2] In other words, the wealth owned by this class of the population is not evenly distributed. Some are enormously wealthy; others are comparatively poor. According to Dr. W. I. King, whose percentages I am quoting, the poorest 80 per cent of our popu'ation owns but 25 per cent of the country's wealth, while the wealthiest 1 per cent owns 33 per cent. These facts are brought forward to show that in relation to wealth the employer class in the population is very much smaller than the employee. From this it follows that when jobs are available at all, the smaller group of employers has the power to supply or deny them to the very much larger group of employees. A large percentage of these employees are loyal, stable workers, men and women who are essential to the success of business and who have placed all dependence for a livelihood upon the hope of being continuously employed. To them industry certainly owes all that it can safely afford to help safeguard

[2] See paper entitled "Wealth Distribution in the Continental United States at Close of 1921," by Dr. W. I. King. Journal of the American Statistical Association, June, 1927.

them from unemployment and the interrupted income that accompanies it.

### WHO ARE THE STABLE WORKERS?

Has any effort been made by industry or by individual units of industry to determine who its stable workers are, and what the cost of giving them a certain, definite amount of assistance would be? Unfortunately, the answer to this question, except in a very few isolated cases, is in the negative. The reason for this is not hard to find. Our society and government are based on democratic principles. The early settlers came to our shores in centuries past filled with a longing for individual liberty. A nation was built upon that foundation rock. For a hundred and fifty years this principle has been cultivated and nourished, until today it is deeply rooted in the heart and mind of every citizen. We all desire to be left alone, unrestrained in our thoughts and actions. We unconsciously resist guidance, advice, and precedent, and secretly applaud as each generation demands more freedom than the last.

The result is that whereas industry has made ample provision for safeguarding all inanimate assets in its possession, it has left its human assets to shift for themselves. It has done this on the theory that the employees on its payrolls must be treated as human beings and not as machines and animals. Rugged individualism is the cry, and it would be a compelling one if all of our citizens were endowed with equal opportunities and equal abilities. But we are not so endowed, and when the misfortune of unemployment comes the distress that follows varies widely and in accordance with our economic circumstances. Industry, of course, cannot furnish safeguards to alleviate all of this distress. It can do its part, however, and by so doing avert, in all probability, having the whole burden thrust upon it. Let us consider some figures.

In round numbers, there are 50 million gainfully employed in the United States; 11 million are engaged in farming; 10 million in manufacturing; 3 million in transportation; 4 million in building; 1 million in mining; 21 million are lumbermen, fishermen, servants, merchants, brokers and bankers, professional men, and government employees. Of this vast population, estimates of the unemployed during the present depression have varied between 3 million and 8 million. The correct figure is probably in the neighborhood of 5 million, and of this number perhaps 10 per cent, due to thrift and forethought, are well able to take care of themselves.

No one knows how to get at exact figures. They change hourly. Men and women are constantly being admitted to new employment and being retired from old. Others are quitting their work voluntarily, entering and retiring from businesses of their own, falling ill, and dying. Only by the law of averages can we make even an estimate of the number or character of the unemployed. Applying this law and placing the number of unemployed at 5 million, we can arrive at the following percentages and classifications:

That 25 per cent (or 1,250,000) of the unemployed will not work or are otherwise unemployable.

That 35 per cent (or 1,750,000) are what might be termed unstable or nomadic workers—men and women who do not want continuous employment; who desire to work one place in winter and another place in summer; who like to flit about from place to place and from job to job. Many of them are alien casual laborers engaged in construction work in the cities, on the railroads, and on the farms—workers who produce the enormous labor turnover figures in industry during periods of prosperity. It is they who are most benefited by municipal appropriations and bond issues voted for unemployment relief.

The remainder, 40 per cent (or 2,000,000), are stable employees—loyal men and women who are settled in their habits and want to work; who are raising families and building homes; who have established positions in the community and adopted standards of living that they desire above all things to maintain. They are absolutely essential to the success of industry in normal times. It is a serious matter to them, to industry, and to the community in which they live, when they are thrown out of employment.

### INDUSTRY'S RESPONSIBILITY TO STABLE WORKERS

No one will claim that industry is directly responsible for furnishing a livelihood to the first group—needy persons who won't work or are unemployable. They are a charge upon all society, employees as well as employers.

Nor is industry directly responsible to the second group, the unstable or nomadic workers—the men and women who voluntarily limit their time of service on any job to periods of days and months rather than years. We must not belittle this class, however. It is the mobile part of our labor supply and is, therefore, very important. But it can hardly be a charge upon industry alone. Its distress during an unemployment crisis must be alleviated by all society through the medium of public works that have been planned in advance and that can be released for definite construction during depression periods. It is said with some degree of justification that this group is being better provided for during the present depression than any other. Public moneys expended on projects for unemployment relief attract workers from this class more than from any other, and oftentimes provide winter work for certain ones who normally are idle during that season.

The third group, made up of the stable workers in industry, offers the most serious problem of all. It embraces the so-called white-collar worker, the settled citizen and home builder—men and women who want to work and who constitute a wholesome part of our society. It is a distressing thing to see them absorbing the savings of a lifetime, losing their homes, or being forced to move to other quarters or other places, all because of unemployment that was forced upon them by causes wholly economic and entirely beyond their control. The old notion that they should always be

prepared through thrift and prior savings to weather economic storms is only partly justified. Illness, inability to earn an adequate sum to enable them to create a surplus, shortness of earning period prior to the coming of a business depression, and major and minor economic changes all have an effect upon their preparation and well-being.

For some time I have felt that a certain portion of these employees whose incomes are substantially limited should receive special consideration from their employers during periods of depressed business. I have always had to admit, however, that I did not know just who the stable workers were or what percentage they represented of the total employed forces of industry. When the present depression began I made up my mind to reach an answer to this perplexing question in my own company, and at the same time obtain data that would help to determine the cost of any relief plan that might later be proposed. I felt that there was no time so propitious as a major depression period to make a study of unemployment phenomena. Data obtained at that time would certainly be conclusive. Fortunately, I was in a position to make this study without any interference. My company, too, was seriously affected by the depression. Though small, it employed a wide range of employees, from highly paid skilled workers at the one extreme to casual laborers at the other. Finally, it was a business that had risen to the greatest heights in its history in 1929, so that the adjustment it had to make was maximum.

## A Study of Actual Conditions

The objectives of the study that we made and are still making were threefold:

(1) To establish and maintain records that will help us to spread available work intelligently and fairly when the factory is running short time.

(2) To produce facts that will definitely show who our stable workers are and that will enable us to establish a rule by which they can quickly be determined at any time.

(3) To obtain actuarial data that will enable us, at the end of the depression, to know with close accuracy what reserves must be provided to tide this stable group of workers over a substantial part of the next depression period if and when it comes.

Our business began to decline in March of 1929. The decline was very slow, however, and was hardly observable before July. The terrific speculative orgy that the country was embarked on at the time made us feel that some sort of an adjustment was in the offing. To prepare for this we adopted the policy of not replacing those persons who voluntarily quit. It is quite surprising how rapidly the number of employees on a payroll, during prosperous times, will decline when a non-replacement policy is put into practice. By February, 1930, our force had declined 14 per cent. Business picked up then and enabled us to keep our remaining force on full time until the last week in June, 1930. At that time the full impact of the depression struck us and we were forced to put our shop on part time. Some of the force did not like this and dropped out in the thought that they could get full-time work elsewhere. As the months passed, others left to enter school, get married, move out of town, or for other reasons. It was also necessary to dismiss a person now and then for gross infraction of rules that could not be overlooked. By March, 1931, the June, 1930, force had been depleted approximately 15 per cent. Altogether this made a reduction from June, 1929, to March, 1931, of 26.8 per cent of those on the payroll at the former date. During the same period our business declined 50 per cent. Since June, 1930, however, our force, including office workers and foremen, has been on short time, augmented by hundreds of hours of odd-job work.

A word about these odd jobs will not be out of place. Some of our best-paid and most highly skilled workmen did them, and, in some cases, received less than half their regular wages for the effort. The jobs represented a wide range of endeavor: painting, carpenter work, steam fitting, bricklaying, ironwork, cement work, reinstalling of machinery, electrical work, tinwork, floor cleaning, window washing, etc. In one case these men removed four great brick supporting pillars and substituted cast-iron columns to conserve space. The spirit of the men who did these jobs was very fine. This, I believe, can be laid to the fact that the superintendent and foremen entered into the spirit of the thing with great zest and took a hand in the work themselves. No man was urged to accept the work, but was simply given the opportunity to do so, and only those with dependents to support were given the privilege. The system we used for spreading this and regular work, which will be described later, was so simple and fair that after more than a year not a single complaint has been registered.

## Setting Up the Records

From June, 1930, to the present we have kept a running weekly record (see accompanying table) of the precise amount of time worked and wages received weekly by each workman in the factory who has been on short time. The record shows the age of the employee, the number of dependents he must support, the date when he was employed by the company, and a brief statement of his special abilities. The record also shows the amount of money that he was paid weekly and the precise number of hours that he worked, so that a curve can be drawn showing precisely how the depression has affected him to current date in so far as income and hours worked are concerned. After each nine-week period percentages are calculated to show the percentage to normal of the time he has worked and the wages he has received during that period. There is no significance in the nine-week period. The record sheets simply admit of that number of weeks per page, and a new page is not started until the percentages on the old are figured and set down. These records are drawn up by departments and, of course, can be combined to show

TYPICAL RECORD OF TIME WORKED AND WAGES OF MEN ON PART TIME

| Employee's name | Age | Dependents | Man's No. | | Week ending May 2 | May 9 | May 16 | May 23 | May 30 | June 6 | June 13 | June 20 | June 27 | Totals, 52 weeks | Average hours worked and wages received per week during depression[a] | Normal full-time hours and earnings per week | Percentage to normal of hours worked and wages received during depression[a] | Remarks | Date employed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chas. Jones | 29 | 0 | 1 | Hr. | 27.0 | 27.0 | 27.0 | 27.0 | 27.0 | 27.0 | 27.0 | 27.0 | | 1452.6 | 27.4 | 50.0 | 55 | | 6-30-20 |
| | | | | Amt. | 16.20 | 16.20 | 16.20 | 16.20 | 16.20 | 16.20 | 16.20 | 16.20 | | 855.36 | 16.40 | 30.00 | 55 | | |
| Wm. Smith | 49 | 2 | 3 | Hr. | 45.0 | 41.0 | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 | | 2305.2 | 44.5 | 50.0 | 89 | Versatile | 7-12-12 |
| | | | | Amt. | 36.00 | 32.80 | 36.00 | 36.00 | 36.00 | 36.00 | 36.00 | 36.00 | | 1847.12 | 35.50 | 40.00 | 89 | | |
| Louis Katen | 71 | 0 | 4 | Hr. | ... | 27.0 | 27.0 | ... | 27.0 | ... | 27.0 | ... | | 900.0 | 17.3 | 50.0 | 35 | | 8-16-09 |
| | | | | Amt. | ... | 12.69 | 12.69 | ... | 12.69 | ... | 12.69 | ... | | 423.00 | 8.15 | 23.50 | 35 | | |
| James Kelley | 32 | 3 | 5 | Hr. | 27.0 | 27.0 | 36.0 | 54.0 | 45.0 | 54.0 | 54.0 | 27.0 | | 1750.5 | 33.6 | 50.0 | 67[b] | | 5-20-23 |
| | | | | Amt. | 20.25 | 20.25 | 24.75 | 33.75 | 29.25 | 33.75 | 33.75 | 20.25 | | 1272.37 | 24.50 | 37.50 | 65 | | |
| Fred Coe | 35 | 2 | 6 | Hr. | 39.0 | 45.0 | 66.0 | 50.0 | 57.0 | 45.0 | 52.2 | 27.0 | | 2159.3 | 41.3 | 50.0 | 83[b] | Very needy | 3-15-20 |
| | | | | Amt. | 23.28 | 26.28 | 36.78 | 28.78 | 32.28 | 23.34 | 29.32 | 17.28 | | 1280.73 | 24.60 | 32.00 | 77 | | |
| John Grillo | 59 | 2 | 7 | Hr. | 27.0 | 27.0 | ... | 27.0 | ... | 27.0 | ... | 27.0 | | 1037.4 | 19.9 | 50.0 | 40 | | 4-6-01 |
| | | | | Amt. | 14.85 | 14.85 | ... | 14.85 | ... | 14.85 | ... | 14.85 | | 570.55 | 10.95 | 27.50 | 40 | | |
| Tony Marso | 48 | 4 | 8 | Hr. | 41.0 | 45.0 | 54.0 | 54.0 | 46.0 | 54.0 | 54.0 | 45.0 | | 2196.4 | 42.0 | 50.0 | 84[b] | Very needy | 6-3-15 |
| | | | | Amt. | 25.36 | 27.36 | 31.86 | 31.86 | 28.11 | 31.86 | 31.86 | 27.36 | | 1431.78 | 27.60 | 34.00 | 81 | | |
| Peter Audi | 52 | 2 | 9 | Hr. | 27.0 | 27.0 | 27.0 | 27.0 | 45.0 | 36.0 | 27.0 | 27.0 | | 1587.7 | 30.3 | 50.0 | 61 | | 2-4-14 |
| | | | | Amt. | 20.25 | 20.25 | 20.25 | 20.25 | 29.25 | 24.75 | 20.25 | 20.25 | | 1184.02 | 22.80 | 32.50 | 61 | | |
| Thomas Casey | 26 | 0 | 10 | Hr. | 9.5 | ... | ... | ... | ... | ... | ... | ... | | 1243.0 | 24.0 | 50.0 | 48 | | 1-8-27 |
| | | | | Amt. | 5.85 | ... | ... | ... | ... | ... | ... | ... | | 811.80 | 15.60 | 28.50 | 48 | | |
| Walter Hess | 50 | 4 | 12 | Hr. | 27.0 | 27.0 | 27.0 | 27.0 | 27.0 | 27.0 | 27.0 | 27.0 | | 1529.3 | 29.3 | 50.0 | 59 | Thrifty | 7-6-15 |
| | | | | Amt. | 15.39 | 15.39 | 15.39 | 15.39 | 15.39 | 15.39 | 15.39 | 15.39 | | 871.70 | 16.70 | 31.00 | 59 | | |

[a] The depression is taken to have begun when hours in the plant were shortened, that is, June 27, 1930.
[b] These percentages differ because this man was given extra work at an hourly rate that was less than his regular rate.

the effect of the depression on the business as a whole. Naturally, they provide the basis for intelligent distribution of available work in the plant, and in that way they accomplish the first objective of our study.

### Segregating the Stable Workers

The second objective of our study was to determine who our stable employees are and to establish a ready rule for segregating them at any specific time in the future. We have enough data already to answer that question, so far as our plant is concerned. The stable employee in our particular business is the man or woman who has been continuously on the payroll for twelve months or longer just preceding the beginning of a decline in business of proportions severe enough to require a contraction of forces or a lessening of hours. Naturally, this definition only applies to our particular company. It might also apply to competitive companies. It might even be stretched to apply to similar plants of many kinds. It is doubtful if they would admit it, however. Each plant will prefer to work out its own definition.

### Data for Establishing Reserve

The third objective of our study will be accomplished by the percentage data that are accumulating week after week on the record sheets. These percentages represent actuarial data based on the worst employment condition that is likely to descend upon us. No one will deny that plans involving expenditure of funds for unemployment relief should be constructed from the base of the worst condition that is likely to develop. This point cannot be urged too strongly or too often. Data and percentages obtained during such times should be conclusive.

### Adequate Reserve a Small Percentage of Payroll

The experience in our plant has led us to believe that industry can, without very great expense, provide reserves to tide that portion of its stable working force, whose incomes are substantially limited, over extended periods of depressed business and pay reasonable dismissal wages to those who are dropped from the payroll entirely. Not only would such a practice relieve a substantial portion of distress that accompanies unemployment, but it would also assist in maintaining the purchasing power of a very important group in our population and thus conceivably narrow the course and extent of the depression itself. It would also offer an incentive to the employer to stabilize his business so as to reduce the amount of benefits he must pay, and at the same time encourage the employee to become a stable worker so that he would be entitled to benefits when depressed business caused his weekly earnings to be materially reduced.

Recently our payroll department calculated from the percentage figures already obtained what would have been necessary in the way of reserves to have maintained the wages of our stable group of employees in office and shop at 80 per cent of normal for those with dependents and 60 per cent of normal for those without for 52 weeks of short-time work. It was quite amazing to us to find that such a reserve would have amounted to but three-quarters of one per cent of the payroll for the years 1923–1929, inclusive. During the same period our company provided in other reserves an equivalent of $13\frac{1}{2}$ per cent of the same group of payrolls. If our experience is at all representative it would seem that industry can well afford to tide its stable group of employees over extended periods of depressed business. It is an obligation, I believe, that industry should voluntarily assume.

In arriving at this conclusion, I have not overlooked the seasonal variations in business and lesser depressions that come along every two or three years, that would absorb some of the reserves during the period of their

accumulation. Nor have I disregarded the more fundamental economic factors, such as unbridled competition and changes in buying habits and demands of the public, that cause profits in some businesses to decline to such an extent as to make a reserve as small as three-quarters of one per cent of the payroll a burdensome load to carry. But if all competitive units in the field were setting up an equal percentage in reserves, there would be no disproportionate load on any one, and the charge could be added uniformly to selling prices. These matters are simply factors in the problem that must be taken into account when benefits and period of time they shall continue are being worked out and established.

### Problem of the Unstable Worker and the Unemployable

With the stable workers reasonably assisted by industry directly, the problem presented by the unstable or nomadic worker and the unemployable would not be so difficult. During great unemployment crises these groups must be cared for by forwardly planned public works, and for those who are mentally and physically unfit charity and institutions maintained for the purpose must be depended upon to give the required assistance. Much can be said for intelligent forward planning. Every important industrial center should have its permanent planning board made up of private citizens that would list and investigate all suggestions and proposals for public improvement, cull out the doubtful ones, and prepare plans of those projects that are worthy but that can be delayed, and have them ready for the time when public funds must be provided for unemployment relief. Such forward planning would enable cities to get some benefit from money paid out for relief and obviate the need for resorting to disgusting subterfuges to make the unemployed feel that they are working for what they are being paid.

### A Program for Industry

Let us now recapitulate. Industry should determine who its stable workers are and voluntarily accept the responsibility for protecting a goodly share of their income during extended periods of depressed business. Studies to determine who the stable employees are and what it would cost to protect their incomes in definite percentages of normal pay over definite periods of time should be made by each unit of industry during the present depression in order that maximum conditions shall be taken into account. When the depression is over, plans for meeting the next one should be made, using data obtained from these studies as a basis.

These plans should have as their base a stabilization program, so drawn as to offer maximum incentive to both employee and employer to regularize incoming business and maintain employment. They should provide for a trusteed reserve fund to be set aside during the next cycle of prosperous years, that can be used at the needed time to maintain the income of stable workers whose incomes are substantially limited, at stated percentages of normal for definite and predetermined periods of time, and to pay dismissal wages to those who are dropped entirely. Whether the reserve funds shall be created jointly by industry and those employed by industry, is a question for individual units of industry to decide. Some will take one view and some another. There are arguments on both sides. It seems clear to me that if contributions are to be made by both employee and employer, the two funds should be kept separate, under separate fixed trust agreements that would provide safeguards peculiar to the special needs of the makers.

This, in my opinion, is the direct and pressing obligation of industry in the problem of mitigating the scourge of unemployment. In addition, of course, it must bear (as it is doing at present) its part of the general burden of relief for those who do not come within the definition of stable workers. It must contribute its share to charity, and it must bear its rightful proportion of taxation to finance forwardly planned public works.

### Social Legislation the Alternative

It will be said that there is not a beggar's chance of industry's doing this thing voluntarily. That may be true, but let us hope not. If it is true, then this country is headed directly for some sort of so-called compulsory public unemployment insurance that will force upon industry a disproportionate amount of the load. Advocates of such insurance will not admit that the load will bear unfairly on any one, and will point out that the law will amply provide against paying benefits to the unworthy. Perhaps the law will at first, but if past experience repeats itself and politics plays true to form, the time will come when everybody will be included and benefits will be increased and prolonged. All of us are familiar with the experience in England where this type of insurance has been a policy of the government since 1911. The first bill was carefully designed and took into account most of the principles of social justice. It encouraged the well-managed company that voluntarily took care of its employees, and provided incentives for improvement in the badly managed company that did not. But as time went on and conditions changed politically and otherwise, all these incentives to better management were withdrawn. Today, unemployment insurance in England is a misnomer. It is not insurance at all, but rather a relief measure which imposes a tremendous tax upon industry and those employed by industry to furnish funds for poor relief. Let us have none of that. Let industry solve its own problem, if necessary under regulatory laws that will make all units of industry accept the principle uniformly. But let industry do the job.

### Regulate Reserve Accounting System

Do I see ears prick up and heads shake at the suggestion of regulatory laws? No one can be blamed if they do. We have good reason to quaver at the thought of added laws. But if unemployment insurance comes we shall have many more laws and regulations, and industry will have precious little to say what they shall

be. If the principle of setting aside reserves during prosperous years to assist stable employees over depressed business periods is accepted by industry, perhaps it would be good to have their amount regulated by law (much as tax liabilities are now) so that all competitive units of industry would be on precisely the same basis. And while we are at it, we might standardize and regulate other reserves at the same time. Nothing would do more to curb unbridled competition, which undoubtedly plays a large part in bringing on depressions. The spectacle of concerns fighting and knifing each other for business and forcing wages to bare existence levels is not a hopeful sight in a country that is trying to solve its labor and unemployment problems. The right of one business to omit well-known reserve items from its costs in order to undersell another must be denied. The practice of new concerns and old manipulating reserves in order to fool themselves and perhaps others into thinking that they are making profits, will some day not be possible. Such rights and practices have forced many well-intentioned businesses to curtail wages in order to protect profits. They have also misled many innocent investors into buying securities that are greatly overvalued.

So perhaps a well-prepared and judiciously regulated reserve accounting system for business might not be so bad. In its relation to reserves for unemployment benefits it would have the advantage of putting the whole problem up to industry itself and insuring that each unit of industry must meet the same requirements.

It will be said, of course, that there is no difference between so-called public unemployment insurance and a system of regulated and trusteed reserves in individual units of industry to provide unemployment benefits. That is not quite correct. So-called unemployment insurance collects its premiums on the basis of employment in all units of industry to provide a common fund from which to pay benefits to any unemployed person coming within the scope of the law. The able employer who contributes little to unemployment pays as much or more into the fund as the incompetent one who, by bad management, contributes much. Regulated and trusteed reserves would avoid such inconsistencies and force each business, capable of supplying employment at all, to provide for its own stable workers during periods of depressed business on a basis established by the division of industry to which it belongs. If it failed to do so it would be penalized the same as it would be under an unemployment insurance law if it omitted to pay premiums.

The machinery for administering a reserve accounting law is already provided in the division of audit of the Internal Revenue Department. To the present duties of checking income-tax returns this department, with its offices located in all parts of the country, would be charged with the task of checking reserves, as required by law, and reporting inadequacies.

Of course, if industry will do the job voluntarily and without regulation, and adopt and maintain a uniform reserve policy in each competitive field, so much the better. There is no doubt but that it would be perfectly possible to do this. Let individual units of industry start at once to make employment studies from the base of the present depression to determine who their stable employees are. Let the principle of accumulating reserves to assist these same employees, whose incomes lie within certain limits, during periods of depressed business be accepted by industry as a whole. When this is done, let specific plans to discharge the obligation be worked out in conference between units of each industrial group. Government should permit, and even encourage, such conferences and assist in them. Trade associations and chambers of commerce should bring industrial groups together and help them to develop workable plans. The larger companies in industry should take the lead and establish the plan in their own plants. Other important employers should follow suit. With these as a nucleus and with trade organizations urging others to follow, it would not be long before reserves for tiding certain stable workers over extended periods of depressed business would be as common and as completely accepted as a sound business principle as reserves for obsolescence and depreciation and for retirement of debt are now.

## Why Not Use the Mol and Pound-Mol?

ENGINEERS are notoriously slow to adopt new units. Despite the much-vaunted claims for the metric system of weights and measures, American engineers have clung tenaciously to their "pounds and inches." This adherence is due not alone to conservatism, as there are economic reasons why the change of systems is not desirable in this country at the present time. On the other hand, the adherence to old systems and methods in other directions has less reason for its persistence, and, in many cases, the engineer suffers handicaps through their use. A case in point is the common habit of stating gas properties in terms of one pound instead of the mol, which has been generally adopted by chemists and chemical engineers as a measure of gas quantity. The mol is defined as that volume of gas whose weight, in the system of units in use, equals its molecular weight. In the engineers' system of units the mol would be that volume of a gas whose weight equals its molecular weight in pounds.

Since Avogadro's Law can be assumed to hold for most gas conditions with which an engineer has to deal, the volume of a mol is the same for all gases at any given temperature and pressure, as equal volumes contain equal numbers of molecules, hence are proportional in weight to their molecular weights. These facts permit the ready calculation of reactions between bases as in combustion, since only the volumes as indicated by the common chemical formulas are involved. Combustion reactions with solids and liquids may be computed in the same manner by using the pound-mol.—From an editorial in *Power*, September 8, 1931, p. 347.

# The Thermodynamics of High-Pressure Water

## A Physical Explanation of the Variations of Its Thermal Properties, Designed to Afford a Better Understanding of These Properties When Used in Engineering Calculations

By JULIAN C. SMALLWOOD,[1] BALTIMORE, MD.

THE thermal properties of water under pressures greatly exceeding those at which evaporation occurs are becoming of increasing importance and interest in steam engineering. Fortunately, some very complete data are now available from Professor Keenan's publication in the February, 1931, issue of MECHANICAL ENGINEERING.[2] These cover numerically and graphically a sufficiently wide range of pressures and temperatures for all calculations within present engineering practice, but they do not present a physical explanation of the variations of the tabulated quantities. It is the purpose of this article to present a physical picture of these variations which, it is believed, will supplement the mathematical relations from which the variations follow, and will afford a better understanding of the properties when used in engineering calculations.

The following notation will be used:

$p$ = pressure, in pounds per square foot
$v$ = specific volume, in cubic feet per pound
$T$ = absolute temperature, degrees fahrenheit
$t$ = temperature by thermometer, degrees fahrenheit
$s$ = entropy, in B.t.u. per pound per degree
$h$ = enthalpy, in B.t.u. per pound
$c_p$ = specific heat at constant pressure, B.t.u. per pound per degree fahrenheit.

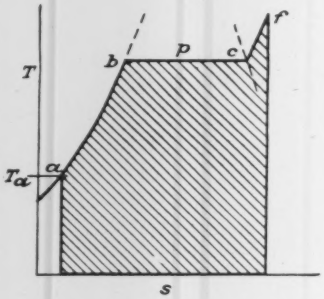


FIG. 1

The mechanical equivalent of heat, 778, will not be employed in the equations, it being understood that the product $pv$ is in B.t.u. instead of foot-pounds wherever it appears in an equation involving heat quantities.

Approaching the subject from the fundamentals, consider first the conventional temperature-entropy ($T$-$s$) diagram for steam, Fig. 1. A state point, $f$, representing superheated steam lies on a constant-pressure line $p$. Another point, $a$, represents water at a temperature $T_a$ above 32 deg., the pressure on the water being that of saturation corresponding to $T_a$. The

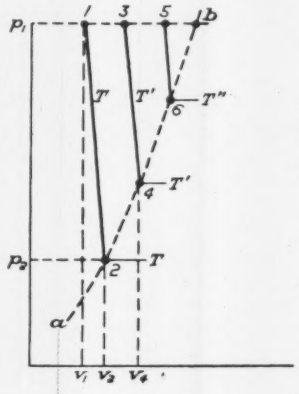


Fig. 2

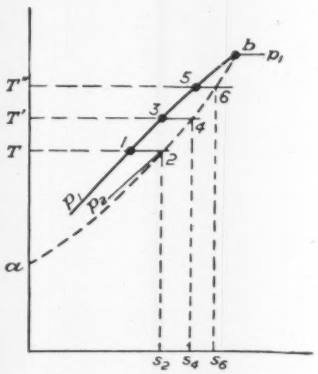


Fig. 3

FIGS. 2 AND 3 CONSTANT-PRESSURE LINES AND ISOTHERMALS FOR WATER. LINE *ab* REPRESENTS SATURATED WATER

line $ab$ is a portion of what is loosely referred to as the "liquid line." It has generally been assumed that the heat added to change the state from $a$ to $f$ at constant pressure is the shaded area under the path $abcf$. This would be true if the line $ab$ depicted a constant-pressure change at pressure $p$. Actually, the line $ab$ does not represent any path of change, but is merely the locus of state points of water under successive pressures corresponding to temperatures at which it will boil. The line is therefore more correctly referred to as the "saturated liquid" line, and the area beneath a portion of it, as $ab$, is *not* the change in heat content (or enthalpy) of the liquid at pressure $p$.

Fig. 2 represents a series of isothermals for water on the pressure-volume ($p$-$v$) plane. Point 1 represents water at a high pressure $p_1$, and at a temperature $T$. The corresponding specific volume is $v_1$. Imagining the pressure to be released at constant temperature, the volume of the water will increase, by virtue of its elasticity, very slightly because of the small change of volume with pressure, but, nevertheless, definitely. When the pressure has decreased to a value $p_2$ such that the

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[2] Joseph H. Keenan, "Thermal Properties of Compressed Liquid Water," MECHANICAL ENGINEERING, February, 1931, p. 127

water boils at temperature $T$, there is an increase of volume at constant pressure. The point 2 is at a volume $v_2$ and represents saturated liquid at temperature $T$. Similarly, point 4 represents saturated liquid at temperature $T'$, and so on. $v_4$ is greater than $v_2$ for all temperatures above 39.2 deg. fahr. The locus of points such as 2, 4, 6 is the saturated-liquid line on the $p$-$v$ plane.

Consider a point $b$ on this line as represented on both the $p$-$v$ and $T$-$s$ planes, Figs. 2 and 3. It is desired to construct through $b$ on the $T$-$s$ plane a constant-pressure path for the liquid at pressure $p_1$. Such a path is shown through $b$ in Fig. 2, the direction being to the left. This path cuts the isothermals, $T''$, $T'$, and $T$

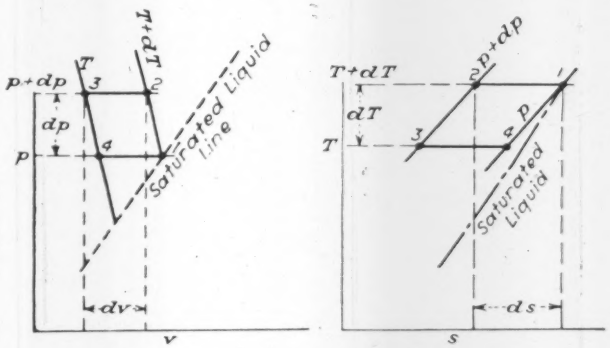


Fig. 4 Fig. 5

FIGS. 4 AND 5

at points 5, 3, and 1. Consequently, successive points on the constant-pressure path will be at successively decreasing temperatures. On the $T$-$s$ plane, the points 5, 3, 1 are located vertically at the corresponding temperatures, and to the *left* of the saturated-liquid line. The $T$-$s$ constant-pressure path at $p_1$ is therefore shown by the line $b$-5-3-1. It remains to find the horizontal distances of 5, 3, and 1 from the saturated-liquid line to locate definitely the constant-pressure path; that is, the dimensions, $s_6 - s_5$, $s_4 - s_3$, and $s_2 - s_1$.

For this purpose, Professor Keenan uses the following thermodynamic relation:

$$\left(\frac{\partial s}{\partial p}\right)_T = -\left(\frac{\partial v}{\partial T}\right)_p$$

The physical interpretation of this is not at once evident. The equation states that the rate of entropy change with pressure when temperature is constant, equals, negatively, the rate of volume change with temperature when the pressure is constant. It is to be observed that the relation connects constant-temperature and constant-pressure changes.

Figs. 4 and 5 show on the $p$-$v$ and $T$-$s$ planes, respectively, two constant-temperature lines 1-2 and 3-4, separated by a differential of temperature; and two constant-pressure lines 2-3 and 4-1, a differential of pressure apart. Point 1 represents saturated liquid. Referring to Fig. 4, let it be imagined that one pound of water at the condition 1 is in the cylinder of a piston feed pump. If this water is compressed isothermally from pressure $p$ to $p + dp$, the path of the change is represented by path 1-2. Let the water at this point be cooled at constant pressure $p + dp$ until its temperature decreases from $T + dt$ to $T$ as shown by the path 2-3. At 3 the pressure on the piston is released, the temperature of the liquid remaining at $T$ until point 4 is reached. From 4 to 1, heat is added at constant pressure $p$, volume increasing, until the initial condition 1 is regained. The pump has gone through a cycle of events represented by the path 1-2-3-4-1, but it is to be noted that no water has been displaced—it remains in the cylinder. The work of the pump is the area included by the paths of the cycle. The corresponding cycle on the $T$-$s$ plane is shown by Fig. 5, and since the processes are reversible, the cycle area on the

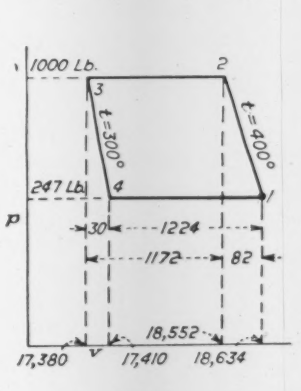


Fig. 6

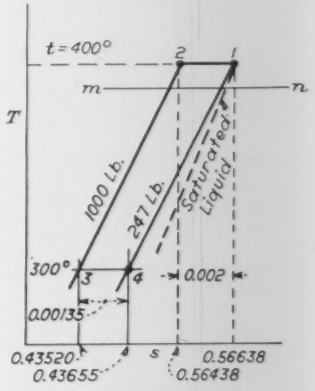


Fig. 7

FIGS. 6 AND 7

[Volumes given in millionths of a cubic foot. Area of $p$-$v$ diagram = 0.167 B.t.u. Area of $p$-$v$ diagram divided by 100 deg. = 0.00167 (entropy). Average width of $T$-$s$ diagram = (0.002 + 0.00135) ÷ 2 = 0.001675.]

$T$-$s$ plane numerically equals, in the same units, that on the $p$-$v$ plane. The areas will be opposite in sign, and from dimensions of Figs. 4 and 5

$$ds \times dt = -dv \times dp$$

Regarding sign, if an increase is designated by plus and a decrease by minus, the signs are $-ds$, $+dp$, $-dv$, $-dT$. The same conclusion may be formed by observing that in Fig. 4 the cycle is traversed in a counterclockwise direction *up* from the starting point, but in Fig. 5 the direction is anticlockwise, *downward*.

From the equation between areas, it follows that

$$\left(\frac{\partial s}{\partial p}\right)_T = -\left(\frac{\partial v}{\partial T}\right)_p \quad \ldots\ldots\ldots\ldots [1]$$

By reference to Figs. 4 and 5, it is seen that the dimension $ds$, along path 1-2, is at constant temperature, and the dimension $dv$, along the path 2-3, is at constant pressure.

The right-hand member of this equation is proportional to the coefficient of cubical expansion of water. The Keenan table of properties of compressed water shows it to vary not only with the temperature but with the pressure. Consequently the entropy dimensions of points on a constant-pressure line, measured from the saturated-liquid line, as dimension 2-1, of point 1, Fig. 3, will vary.

Figs. 6 and 7 are dimensioned with values from the Keenan table. The horizontal paths are correctly shown as straight; the sloping paths should be curved, but are drawn straight for an approximate comparison. The area on the $p$-$v$ plane, expressed in B.t.u. divided by the range of temperature, 100 deg., gives, approximately, the average width (entropy) of the area on the $T$-$s$ plane. If the range of temperature were taken, not from 400 deg. to 300 deg. but from 400 deg. to 400 deg. $- dT$, as shown by the line $mn$, Fig. 7, then the true entropy dimension of point 2, at 1000 lb. and 400 deg. from the saturation line, could be calculated. Thus, from Equation [1],

$$s_2 - s_1 = -\int_{p_1}^{p_2} \left(\frac{\partial v}{\partial T}\right)_p dp$$

and this entropy difference is negative since $s_1 > s_2$ for temperatures above 39.2 deg. fahr.

The specific volume of water decreases with its temperature until 39.2 deg. fahr., the temperature of maximum density, is reached. Further lowering of temperature to 32 deg. results in an increase of volume. Consequently the rate $dv/dT$ is zero at 39.2 deg., and negative between 39.2 deg. and 32 deg. It follows that the entropy difference between compressed water and water at the saturation pressure, at a temperature of 39.2 deg., is zero; and below that temperature to 32 deg., it is positive. Therefore, assuming that maximum density occurs at 39.2 deg. at all pressures, all of the constant-pressure curves of compressed water intersect and cross at 39.2 deg. on the saturation line. This is depicted by Fig. 8.

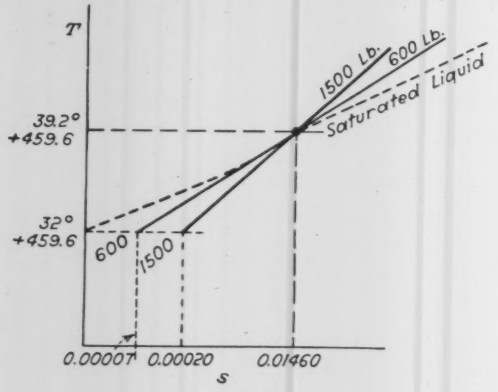


FIG. 8

Fig. 9 shows the cycle previously discussed in three different locations, $A$, $B$, and $C$. At $A$ the constant-pressure change 2-3 to a lower temperature is accomplished by a *reduction* in volume. At $B$ the corresponding change (at 39.2 deg.) is accompanied by no change in volume since the saturation line curves to the right; the area of the cycle is zero, and the entropy change is therefore zero. At $C$ the constant-pressure change from, say, 36 deg. to 34 deg. along 2-3, can only be effected by an *increase* of volume, the cycle being traversed clockwise. The entropy change, $s_2 - s_1$, therefore changes sign and becomes positive.

Turning now to the enthalpy property, the relation employed by Keenan is

$$\left(\frac{\partial h}{\partial p}\right)_T = v - T\left(\frac{\partial v}{\partial T}\right)_p \quad \ldots\ldots\ldots\ldots [2]$$

This proceeds from the general thermodynamic equation

$$dh = c_p dT - \left[T\left(\frac{\partial v}{\partial T}\right)_p - v\right]dp$$

The application is for a differential of enthalpy of water

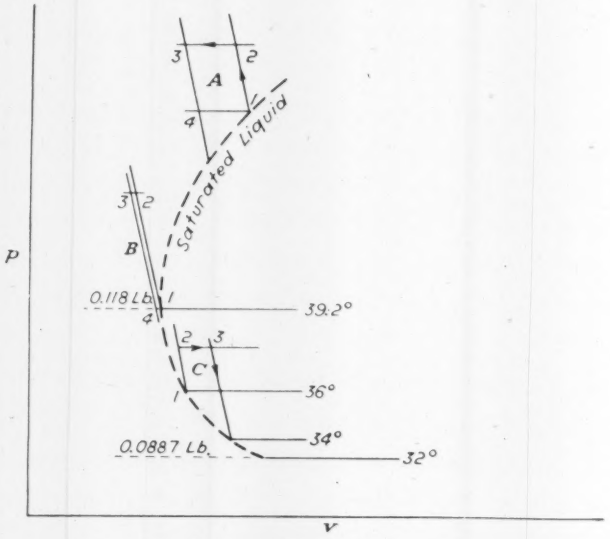


FIG. 9

at constant temperature, or, referring to the path 2-1, Fig. 3,

$$\int dh = h_1 - h_2$$

that is, the change in enthalpy between high pressure and saturated water at the same temperature $T$. This quantity may be plus or minus, depending upon the relative magnitudes of the areas under the two constant-pressure curves, $p_1$ and $p_2$, extended to zero enthalpy.

In the general equation, since the temperature is constant, $dT = 0$, $c_p dT = 0$, and by transposing, Equation [2] results. In Equation [2], for $-\left(\frac{\partial v}{\partial T}\right)_p$ may be written its value $+\left(\frac{\partial s}{\partial p}\right)_T$ as shown by Equation [1]. Then

$$\left(\frac{\partial h}{\partial p}\right)_T = v + T\left(\frac{\partial s}{\partial p}\right)_T$$

This is essentially a constant-temperature process; therefore

$$dh = vdp + Tds$$

and

$$h_2 - h_1 = \int_{p_1}^{p_2} vdp + T(s_2 - s_1) \ldots\ldots [3]$$

The interpretation of this quantity can best be made by reference to the $p$-$v$ and $T$-$s$ diagrams, Figs. 10 and 11. The integral of $vdp$ is seen to be the area included by the projection of the isothermal path 1-2 and the $p$-axis. Inspection shows this area to be the foot-pounds of work done by a pump supplied with one pound of water on the suction stroke at pressure $p_1$, discharged at pressure $p_2$, and compressed *isothermally* from saturated volume at $p_1$ to the higher pressure $p_2$. In Equation [3] this work appears with a positive sign since $p_2 > p_1$. Fig. 11 discloses the integral of $Tds$ to be the heat withdrawn from the water during its rise in pressure in order to maintain isothermal compression. Since $s_2 < s_1$, this heat quantity is negative for temperatures above 39.2 deg. fahr. Equation [3] may be expressed thus:

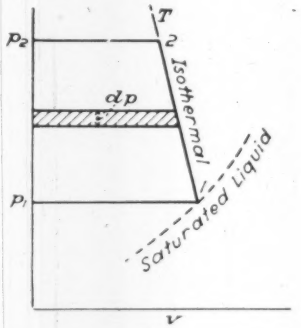


Fig. 10

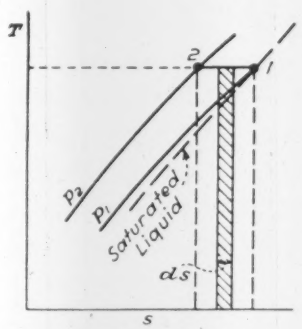


Fig. 11

FIGS. 10 AND 11

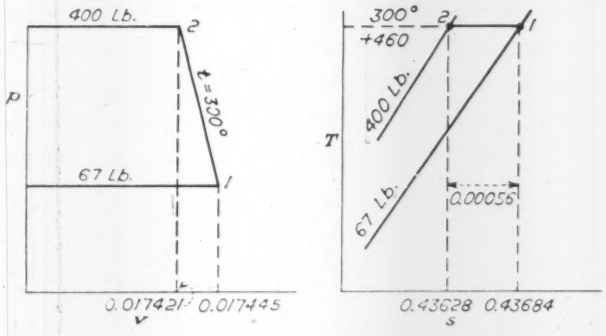


FIG. 12

[Area of $p$ $v$ diagram = 1.07 B.t.u. Area $T(s_1 - s_2)$ = 760 × 0.00056 = 0.43 B.t.u. Difference = 0.64 B.t.u. From tabular values, $h_2 - h_1$ = 270.08 − 269.47 = 0.61 B.t.u.]

$$h_2 - h_1 = \int_{p_1}^{p_2} vdp - T(s_1 - s_2) \ldots\ldots [4]$$

that is, the difference between the enthalpy of high-pressure water and saturated water at temperature $T$ equals the work done by the feed pump in displacing the water from the saturation to the higher pressure *isothermally*, less the heat removed during the isothermal compression.

The quantity $h_2 - h_1$ is negative, zero, or positive, depending upon the relative magnitudes of $\int vdp$ and $T(s_1 - s_2)$. According to the Keenan table and charts, the dividing line is at about 500 deg. fahr. Thus:

At 100 deg., enthalpy of 2500-lb. water is 6.68 B.t.u. greater than that of saturated water.

At 500 deg., enthalpy of 2500-lb. water is 0.31 B.t.u. less than that of saturated water.

At 500 deg., enthalpy of 6000-lb. water is 0.77 B.t.u. greater than that of saturated water.

At 650 deg., enthalpy of 2500-lb. water is 4.80 B.t.u. less than that of saturated water.

That is, high-pressure water at temperatures less than 500 deg. has greater enthalpy than saturated water; at 500 deg. the enthalpy is nearly equal; and above 500 deg., the enthalpy of high-pressure water is less than if saturated.

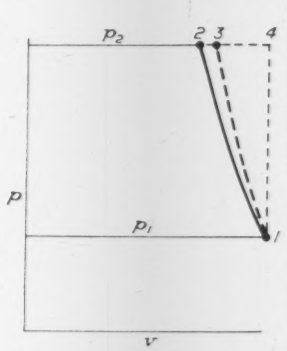


Fig. 13

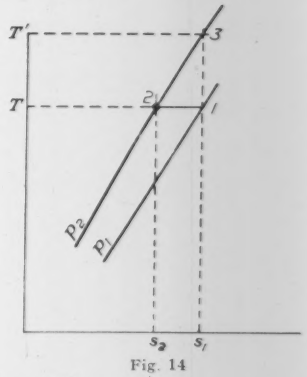


Fig. 14

FIGS. 13 AND 14

It is interesting, incidentally, that the enthalpy of 32-deg. water at 2500 lb. is 7.49 B.t.u. greater than for saturated water at 32 deg., and at 6000 lb. it is 17.6 B.t.u. greater.

Fig. 12 shows the application of dimensions to the $p$-$v$ and $T$-$s$ diagrams, whereby the enthalpy difference between 400 lb. and saturation pressure (67 lb.) at 300 deg. may be calculated approximately.

A further study of Equation [4] may be made in connection with the $p$-$v$ and $T$-$s$ diagrams. Referring to Figs. 13 and 14, on the $T$-$s$ plane, the area included between the two constant-pressure lines, $p_1$ and $p_2$, extended to zero enthalpy, and the isothermal 1-2 equals the area of the $p$-$v$ cycle, bounded similarly, expressed in heat units. This $T$-$s$ area (Fig. 14) also equals the area under 1-2 + area under $p_2$ to 2 — area under $p_1$ from 1, or

$$\text{Isothermal feed-pump work} = T(s_1 - s_2) + h_2 - h_1$$

which is a rearrangement of Equation [4].

If the feed pump compresses the water adiabatically from the saturated condition at point 1 to the pressure $p_2$, the path 1-3 (Fig. 14) will be traversed, and the adiabatic work of the feed pump is the area included between the constant-pressure lines $p_1$ and $p_2$ and the constant-entropy line 1-3. This area is greater than the isothermal-work area by the triangle 1-2-3. Also

$$\text{Area 1-2-3} = (h_3 - h_2) - T(s_1 - s_2)$$

Adding this to the expression for isothermal work, it

appears that to compress saturated water from pressure $p_1$ at temperature $T$ to pressure $p_2$ at temperature $T'$ adiabatically, the energy required is

$$T(s_1 - s_2) + h_2 - h_1 + h_3 - h_2 - T(s_1 - s_2) = h_3 - h_1$$

Professor Keenan shows that the temperature rise of the water under these conditions is about one degree when the compression starts at a saturated pressure at about 100 deg. and is carried to the critical pressures. The temperature rise increases, with the same upper limit, as the saturation pressure increases, being about 10 deg. at 1500 lb. Nevertheless the adiabatic work of the feed pump is not greatly different from the constant-volume work calculated as indicated by the $p$-$v$ area of Fig. 13, $p_1$-1-4-$p_2$.

The following calculations illustrate the use of the Keenan Table of Properties of Compressed Liquid.

(1) How much heat is added to 1 lb. of water supplied to a boiler under a pressure of 2500 lb., the temperature of the feedwater being 300 deg. and of the steam, 750 deg.? The enthalpy of the steam is 1250.2 B.t.u., and of the water, from the compressed-liquid table, is 274.02 B.t.u.; the difference, 976.18 B.t.u., is the heat added. This is 4.55 B.t.u. less than would appear if the enthalpy of saturated water at 300 deg. (269.47) had been used in the calculation.

(2) For the preceding data, calculate the heat equivalent of the feed-pump work, assuming an efficiency of 80 per cent and that the pump is supplied with water at the saturation pressure corresponding to 300 deg. This pressure is 67 lb. Assuming constant-volume work as in area $p_1$-1-4-$p_2$, Fig. 13, the volume is 0.017445, and the ideal work, in heat units, is $144\ (2500 - 67) \times 0.017445 \div 778 = 7.85$ B.t.u. Allowing for the efficiency, the energy required for the feed pump is $7.85 \div 0.80 = 9.81$ B.t.u.

(3) What is the energy necessary for the feed pump if the water is compressed adiabatically, using the same data, and what is the temperature rise? The entropy of saturated water at 300 deg. is 0.43684. The temperature of water at 2500 lb. and this same entropy value may be found by interpolating in the compressed-water table between the values in the 300-deg. and 400-deg. columns on the 2500-lb. line, and is found to be 303.32 deg. A similar interpolation for the enthalpy of water at this temperature and at 2500 lb. results in the value 277.46 B.t.u. The difference between this and the enthalpy at saturation, 269.47, equals the ideal work of the feed pump and is 7.99 B.t.u. Allowing for 80 per cent efficiency, the energy required for the pump is nearly 10 B.t.u. The answer obtained in (2) is seen to be two per cent less than this result. According to Fig. 5 of Professor Keenan's paper, the constant-entropy work for this range should be slightly less than the constant-volume work. The discrepancy in the results (2) and (3) is probably due to inaccuracies in interpolation of values from the table for compressed water. Apparently the feed-pump work may be calculated on the old constant-volume basis with negligible error.

(4) Against a boiler pressure of 1500 lb., does it take more power to pump cool water at 100 deg. and 250 lb. than hot water at 400 deg. and 250 lb.? Inspection of the table of compressed-water properties shows that the specific volume at each temperature is very little different from the saturated volume at that temperature. Taking the saturated volumes, the pump will have to displace 0.018634 cu. ft. per lb. at 400 deg., and 0.016131 cu. ft. at 100 deg., a difference of about 0.0025 cu. ft. Consequently, based on constant-volume work, the pump will require $0.0025 \div 0.016131$, or 15.5 per cent more energy to discharge 1 lb. of the hot water than the cold. The power required per cubic foot, or per gallon, however, is exactly the same for hot water as for cold, other physical conditions being the same; the weight discharged per unit of time with a given pump displacement being less with hot water.

(5) How does the change of enthalpy caused by the feed pump affect the heat added in the boiler? Assuming no change of temperature and no pressure drop between feed pump and boiler, the heat added to the feed water is the enthalpy of the steam discharged minus the enthalpy of the water under the pressure-temperature conditions leaving the pump.

If the calculation for heat added is based upon the enthalpy of saturated water entering the boiler, the result is too high for temperatures less than 500 deg. Further, as shown by (3), the adiabatic compression of water results in a rise of temperature above that of the water entering the pump; the heat required from the boiler is a corresponding amount less.

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## The Measurement of Noise

THE "yardstick," or "degree," by which we measure noise, is the "decibel," a simple power ratio or logarithmic unit, whose adoption hinges on the fact that, while the sensation of loudness in the ear advances, the energy corresponding increases geometrically by leaps and bounds on a scale which extends over almost astronomical magnitudes.

The amount of energy in most sounds of every-day experience is extremely small. A Final Cup-Tie crowd of 100,000 at Wembley Stadium all talking continously and rather loudly would provide as much speech power as would, if converted, light a small electric lamp throughout the game.

A convenient "noise thermometer" ranges from 0 to 100 decibels—an upper level, which is unlikely to be exceeded in every-day experience. Conversational level is at about the half-way point—50 db.

Among the loudest things one is likely to encounter are the noises of riveting, pneumatic road drilling, steamship sirens, and printing presses. More untoward encounters are lions and the Niagara Falls, which can, apparently, roar equally loudly (85 db.). But the arch offender of all is the airplane engine at close quarters (110 db.). The noise in the cabins of airplanes in flight ranges between 80 db. and 100 db.—*The Engineer*, May 15, 1931, p. 554.

# Diphenyloxide for Preheating Air

## First Large-Scale Operation of a Power Plant Employing a High-Boiling-Point Organic Compound as a Heat-Transfer Agent Is at Bremo Station of Virginia Public Service Company

By JOHN J. GREBE,[1] MIDLAND, MICH.

USE of diphenyloxide for preheating air at the Bremo Station of the Virginia Public Service Company marks the first large-scale operation of a power plant employing a high-boiling-point organic compound. The field of high-boiling organic heat-transfer agents has been so enticing that many proposals have been made and a considerable amount of experimental work has been done to determine their applicability. A brief summary of such uses will be given, as well as a description of the nature and type of apparatus required.

The fundamental reasons for considering the use of diphenyloxide, diphenyl, and mixtures of these with naphthalene for heat-transfer purposes are that they permit operation at high temperatures with moderate pressure and that these particular compounds are more stable than others in their boiling range. The thermal and the heat-transfer properties of these compounds are so nearly the same that experience gained on one material can be applied to the others. The Bremo Station uses a mixture of 85 per cent diphenyloxide and 15 per cent naphthalene in order to obtain a eutectic melting at 65 deg. fahr. The eutectic of 74 per cent diphenyloxide and 26 per cent diphenyl melts at 56 deg. fahr. The pure materials have the following properties:

| | Melting point, deg. fahr. | Boiling point, deg. fahr. |
|---|---|---|
| Diphenyloxide | 81 | 496 |
| Diphenyl | 165 | 495 |
| Naphthalene | 176 | 424 |

These compounds are non-corrosive and non-poisonous, so that the equipment required for their use consists of standard steel construction. Except in special cases, there is no advantage in using diphenyloxide where the maximum temperature required is less than 500 deg. fahr.

Above the temperature of 750 deg. fahr., diphenyloxide slowly decomposes to other organic compounds, and then one is faced with the problem of balancing the cost of purification and replacement of the material against the advantages derived. As all know, even water decomposes to form hydrogen and iron oxide unless the necessary precautions are taken.

For very high temperature ranges there is no better heat-transfer medium than mercury, which, being an element, cannot be decomposed. The adaptation of the Brown Boveri boiler or the Loeffler boiler system to the problem of boiling mercury may solve what at present is the most difficult feature in connection with the use of mercury.

It can be seen from the foregoing that any material, be it liquid air, carbon dioxide, ammonia, water, diphenyloxide, or mercury, has its own specific range of temperature within which it is most useful for heat-transfer purposes. The list of suitable heat-transfer fluids could be increased very considerably.

### No Advantage in Superheated Vapor

Heat is transferred preferably by the use of heat of vaporization wherever constant temperatures are required. Where materials are to be heated without evaporation, the sensible heat or the superheat in the heat-transfer materials is generally used in order to permit the use of a counterflow system. In the case of diphenyloxide, there is no advantage in superheated vapor, since the pressure required for saturated vapor at 750 deg. fahr. is only 135 lb. gage. At the Bremo Station (1, 2)[2] the sensible heat of diphenyloxide is used, since it requires simply that the liquid be circulated through economizer tubes for heating and through air-preheating tubes for removing heat from the diphenyloxide. Essentially, the system is a closed heat-circulating system using diphenyloxide liquid to carry heat taken from the flue gases to the combustion air. Since the boiler is of the single-pass vertical type, a conventional air-preheater design would have entailed an increase in building height and expensive duct work. This was avoided by installing a relatively small economizer on top of the boiler, carrying the heat absorbed down to the burner floor in diphenyloxide and releasing it in air heaters placed at the point where the air enters the boiler.

In addition to these advantages, which are peculiar to the Bremo Station, other savings were incorporated in the design and still others were discovered during the period of preliminary operation. The construction of the system presented little in the way of difficulties, actually causing less trouble than the erection of a standard air heater with duct work. The opera-

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Presented at the Kansas City Meeting, Kansas City, Mo., Sept. 7 to 9, 1931, of The American Society of Mechanical Engineers. All papers are subject to revision.

Note: Statements and opinions advanced in papers are to be understood as individual expressions of their authors, and not those of the Society.

[2] Numbers in parentheses apply to the references at end of article.

tion of this new type of air preheater was so facile and trouble-free as to require practically no attention. Boiler-room appearance is greatly improved by the air-heater system, presenting the illusion of being an integral part of the boiler. Another feature is the individual control over primary and secondary air temperatures for each burner. This flexibility makes it possible to obtain maximum efficiency for any load. Cleaning of the apparatus is done with standard soot blowers at the economizer, while the use of clean air removes the necessity for cleaning the air heaters proper. The fan power required for duct-draft losses and the lowering of air temperature due to leakage are, of course, eliminated, while the radiation loss is cut down appreciably. Any increase in efficiency resulting will come from these last three factors.

### LEAKAGE OF DIPHENYLOXIDE A PROBLEM

The only difficulty in the entire installation was the leakage of diphenyloxide through the stuffing boxes on the circulating pump and around valve stems and sight-glass glands. Diphenyloxide has a low surface tension and low viscosity at high temperatures, and consequently requires ample provision for packing. The problem is similar to that of handling kerosene or light oils. The trouble can be substantially eliminated by increasing the amount of packing in all glands.

Enough data were taken to convince every one directly concerned that the air temperatures obtained were satisfactory. Preparations are now being made for a complete thermal study of the system, involving the determination of optimum operating conditions and heat-transfer coefficients.

It is of interest to mention briefly the work done by the Dow Chemical Company in connection with the use of diphenyloxide in its own power plant for superheating and reheating high-pressure steam. The experimental boiler had for its main aim to make high-pressure steam boilers cheaper and safer by the elimination of heavy drums wherever possible. The late Dr. H. H. Dow (3) was thoroughly convinced, from experience on high-pressure tubular chemical reactors, that a boiler similar to the Benson boiler, operating at the pressure desired, instead of throttling from the critical pressure, is not only possible but is practical. In other words, a boiler intended to make 1400-lb. steam should require boiler-feed pumps for not more than 1800 lb. pressure, rather than for 3400 lb. To accomplish this purpose without undue variations in the amount of water entering various parallel strands of tubing, careful checks were made of the pressure drops through the economizer, boiler, and superheater sections of the continuous coils to be used. To increase the heat capacity of such a tubular boiler system in order to be able to take fluctuations in demand with the assurance that no water would enter the turbine and to control the temperature of the superheated steam, a diphenyloxide boiler was combined with the steam boiler. These were so designed that heat could be transferred either from or to the diphenyloxide according to the requirements of the steam. In addition, enough diphenyloxide vapor was to be generated for reheating the steam in the turbine room between the high-pressure and the low-pressure turbines.

While the aim of this experimental boiler was to make possible the design of a power plant that would incorporate a comparatively small amount of diphenyloxide heat-interchange equipment, it was decided

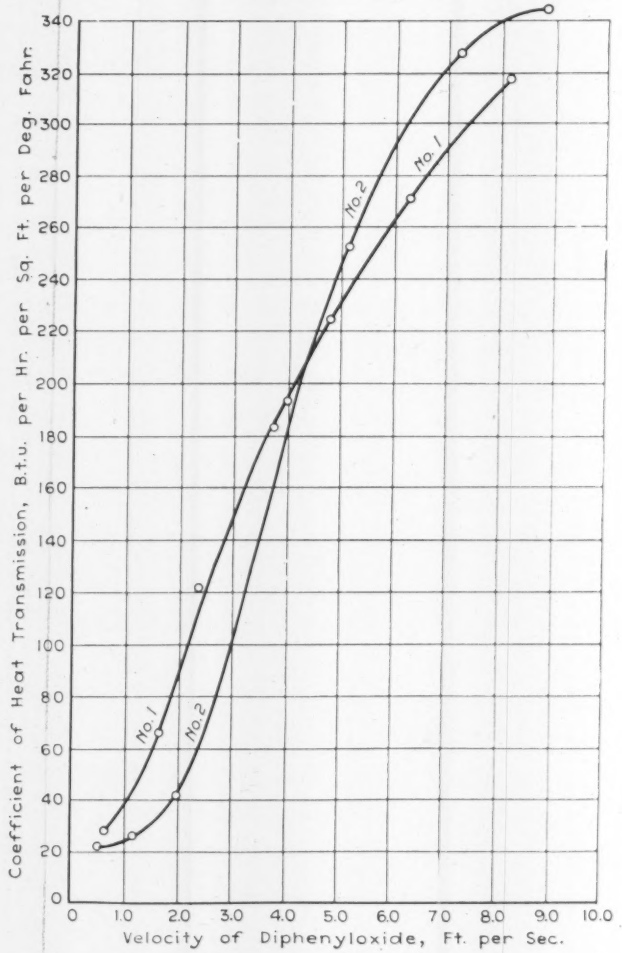


FIG. 1 OVERALL COEFFICIENT OF HEAT TRANSMISSION BETWEEN LIQUID DIPHENYLOXIDE AND STEAM (CONDENSING)

(Separating wall: No. 1, 1/8-in. standard steel pipe; No. 2, 3/8-in. copper tubing; 3/64-in. wall. Unrestricted steam flow on outside of tube. Diphenyloxide, 80 to 280 deg. fahr.)

to make the diphenyloxide boiler as large as possible in order to obtain experience on a large diphenyloxide boiler unit and to combine it with the smallest high-pressure steam boiler and turbine equipment that would be practical.

### BOTH WORKING TOWARD SAME GOAL

However, when one compares the ultimate object of the type of a boiler toward which these experiments were working and the new developments that have been made in the line of high-pressure boilers since the time when this experimental boiler was planned back

in 1926, it is quite obvious that the industry as a whole is coming toward this same goal. Work has been suspended on this boiler for the present, until the demand for power increases.

The experimental boiler was to develop into a large single-pass high-pressure steam boiler with the equivalent of a steaming economizer for practically all of its boiler surface. (See Fig. 2.) A small portion of the water that would not be evaporated in these tubes would be evaporated with diphenyloxide vapor in a drum in which any scale would be formed on the outside of the diphenyloxide coils and settle out to be blown off. The steam would leave this heat-interchanger drum in a superheated condition at a temperature so regulated that the final temperature would be the desirable value regardless of the rating of the boiler.

TABLE 1 PROPERTIES OF SATURATED DIPHENYLOXIDE VAPORS

| Temperature | | Pressure | | Heat content, B.t.u. per lb. | | | Specific heat, | Density, lb. per cu. ft. | |
|---|---|---|---|---|---|---|---|---|---|
| Deg. fahr. | Deg. cent. | Lb. per sq. in. abs. | Vacuum, in. hg. | Liquid | Latent | Total | liquid | Liquid | Vapor |
| 81 | 27.0 | .. | .. | 0 | 146 | 146 | 0.39 | .. | .. |
| 90 | 32.2 | .. | .. | 4 | 145 | 149 | 0.39 | .. | .. |
| 100 | 37.8 | .. | .. | 8 | 145 | 153 | 0.40 | .. | .. |
| 110 | 43.3 | .. | .. | 12 | 145 | 157 | 0.40 | 65.8 | .. |
| 120 | 48.9 | .. | .. | 16 | 145 | 161 | 0.40 | 65.5 | .. |
| 130 | 54.4 | .. | .. | 20 | 144 | 164 | 0.41 | 65.2 | .. |
| 140 | 60.0 | .. | .. | 24 | 144 | 168 | 0.41 | 64.9 | .. |
| 150 | 65.6 | .. | .. | 28 | 143 | 171 | 0.42 | 64.6 | .. |
| 160 | 71.1 | .. | .. | 32 | 143 | 175 | 0.42 | 64.3 | .. |
| 170 | 76.7 | .. | .. | 37 | 143 | 180 | 0.43 | 64.0 | .. |
| 180 | 82.2 | .. | .. | 41 | 142 | 183 | 0.43 | 63.7 | .. |
| 190 | 87.8 | .. | .. | 45 | 142 | 187 | 0.44 | 63.4 | .. |
| 200 | 93.3 | .. | .. | 49 | 142 | 191 | 0.44 | 63.1 | 0.0012 |
| 210 | 98.9 | .. | .. | 54 | 142 | 196 | 0.45 | 62.8 | 0.0016 |
| 220 | 104.5 | .. | .. | 59 | 141 | 200 | 0.45 | 62.5 | 0.0020 |
| 230 | 110 | 0.14 | 29.71 | 63 | 141 | 204 | 0.46 | 62.2 | 0.0030 |
| 240 | 115 | 0.18 | 29.63 | 68 | 140 | 208 | 0.46 | 61.9 | 0.0034 |
| 250 | 121 | 0.23 | 29.53 | 73 | 140 | 213 | 0.47 | 61.6 | 0.0045 |
| 260 | 127 | 0.29 | 29.41 | 78 | 139 | 217 | 0.48 | 61.3 | 0.0056 |
| 270 | 132 | 0.37 | 29.25 | 82 | 139 | 221 | 0.49 | 61.0 | 0.0070 |
| 280 | 137 | 0.47 | 29.04 | 87 | 138 | 225 | 0.49 | 60.7 | 0.0080 |
| 290 | 143 | 0.58 | 28.82 | 92 | 138 | 230 | 0.50 | 60.4 | 0.010 |
| 300 | 149 | 0.72 | 28.54 | 97 | 137 | 234 | 0.50 | 60.1 | 0.012 |
| 310 | 154 | 0.91 | 28.17 | 102 | 137 | 239 | 0.51 | 59.8 | 0.016 |
| 320 | 160 | 1.1 | 27.76 | 108 | 136 | 244 | 0.52 | 59.4 | 0.019 |
| 330 | 166 | 1.3 | 27.36 | 113 | 135 | 248 | 0.52 | 59.1 | 0.022 |
| 340 | 171 | 1.6 | 26.74 | 118 | 134 | 252 | 0.53 | 58.9 | 0.026 |
| 350 | 177 | 1.9 | 26.14 | 124 | 134 | 258 | 0.54 | 58.6 | 0.030 |
| 360 | 182 | 2.2 | 25.53 | 129 | 133 | 262 | 0.54 | 58.3 | 0.036 |
| 370 | 188 | 2.5 | 24.92 | 134 | 132 | 266 | 0.55 | 58.0 | 0.044 |
| 380 | 193 | 3.0 | 23.90 | 140 | 131 | 271 | 0.55 | 57.8 | 0.050 |
| 390 | 199 | 3.5 | 22.88 | 146 | 130 | 276 | 0.56 | 57.5 | 0.060 |
| 400 | 204 | 4.0 | 21.90 | 151 | 129 | 280 | 0.57 | 57.2 | 0.068 |
| 410 | 210 | 4.6 | 20.65 | 157 | 128 | 285 | 0.57 | 57.0 | 0.077 |
| 420 | 216 | 5.3 | 19.20 | 163 | 127 | 290 | 0.58 | 56.7 | 0.090 |
| 430 | 221 | 6.2 | 18.4 | 169 | 126 | 295 | 0.59 | 56.4 | 0.10 |
| 440 | 227 | 7.0 | 15.8 | 154 | 125 | 299 | 0.59 | 56.2 | 0.12 |
| 450 | 232 | 8.0 | 13.7 | 180 | 124 | 304 | 0.60 | 55.9 | 0.14 |
| 460 | 238 | 9.1 | 11.5 | 186 | 123 | 309 | 0.60 | 55.7 | 0.16 |
| 470 | 243 | 10.2 | 9.2 | 193 | 122 | 315 | 0.61 | 55.4 | 0.18 |
| 480 | 249 | 11.7 | 6.2 | 199 | 121 | 320 | 0.62 | 55.2 | 0.21 |
| 490 | 254 | 13.0 | 3.6 | 205 | 121 | 326 | 0.62 | 55.0 | 0.24 |
| 496 | 258 | 14.7 | 0.0 | 208 | 120 | 328 | 0.62 | 54.8 | 0.26 |
| | | | Lb. per sq. in. gage | | | | | | |
| 496 | 258 | 14.7 | 0.0 | 208 | 120 | 328 | 0.62 | 54.8 | 0.26 |
| 500 | 260 | 15.3 | 0.6 | 211 | 119 | 330 | 0.63 | 54.7 | 0.28 |
| 510 | 266 | 16.1 | 1.4 | 218 | 118 | 336 | 0.63 | 54.3 | 0.32 |
| 520 | 271 | 18 | 3.3 | 224 | 117 | 341 | 0.64 | 53.9 | 0.36 |
| 530 | 276 | 20 | 5.3 | 230 | 116 | 346 | 0.64 | 53.5 | 0.40 |
| 540 | 282 | 23 | 8 | 237 | 115 | 352 | 0.65 | 53.2 | 0.44 |
| 550 | 288 | 25 | 10 | 243 | 114 | 357 | 0.65 | 52.8 | 0.48 |
| 560 | 293 | 28 | 13 | 250 | 113 | 363 | 0.65 | 52.4 | 0.54 |
| 570 | 299 | 31 | 16 | 256 | 112 | 368 | 0.66 | 52.0 | 0.60 |
| 580 | 304 | 34 | 19 | 263 | 110 | 373 | 0.66 | 51.7 | 0.67 |
| 590 | 310 | 38 | 23 | 270 | 109 | 379 | 0.66 | 51.3 | 0.75 |
| 600 | 315 | 42 | 27 | 277 | 108 | 385 | 0.66 | 50.9 | 0.88 |
| 610 | 321 | 46 | 31 | 283 | 107 | 390 | 0.67 | 50.5 | 1.00 |
| 620 | 327 | 52 | 37 | 289 | 105 | 394 | 0.67 | 50.2 | 1.10 |
| 630 | 332 | 57 | 42 | 296 | 104 | 400 | 0.67 | 49.8 | 1.17 |
| 640 | 338 | 62 | 47 | 303 | 103 | 406 | 0.67 | 49.5 | 1.24 |
| 650 | 343 | 68 | 53 | 310 | 102 | 412 | 0.67 | 49.1 | 1.29 |
| 660 | 349 | 74 | 59 | 316 | 100 | 416 | 0.68 | 48.7 | 1.34 |
| 670 | 354 | 80 | 65 | 323 | 99 | 422 | 0.68 | 48.3 | 1.40 |
| 680 | 360 | 87 | 72 | 330 | 97 | 427 | 0.68 | 48.0 | 1.5 |
| 690 | 366 | 95 | 80 | 337 | 96 | 433 | 0.68 | 47.6 | 1.6 |
| 700 | 371 | 100 | 85 | 343 | 95 | 438 | 0.68 | 47.3 | 1.7 |
| 710 | 377 | 110 | 95 | 350 | 93 | 443 | 0.68 | 46.7 | 1.8 |
| 720 | 382 | 118 | 103 | 357 | 91 | 448 | 0.68 | 46.3 | 1.9 |
| 730 | 388 | 126 | 111 | 364 | 90 | 454 | 0.68 | 45.8 | 2.1 |
| 740 | 393 | 136 | 121 | 371 | 88 | 459 | 0.68 | 45.3 | 2.3 |
| 750 | 399 | 146 | 131 | 377 | 86 | 464 | 0.69 | 44.8 | 2.5 |
| 760 | 404 | 156 | 141 | 384 | 84 | 468 | 0.69 | 44.4 | 2.6 |
| 770 | 410 | 167 | 152 | 391 | 82 | 473 | 0.69 | 43.8 | 2.7 |
| 780 | 416 | 180 | 165 | 398 | 80 | 478 | 0.69 | 43.3 | 2.9 |
| 790 | 421 | 192 | 177 | 405 | 78 | 483 | 0.69 | 42.7 | 3.2 |
| 800 | 427 | 210 | 195 | 412 | 76 | 488 | 0.69 | 42.0 | 3.5 |
| 950 | 510 | Critical temperature | | | | | | | |

Diphenyloxide liquid would be heated and partly evaporated in another steaming economizer which would cool the gases in the last pass. The diphenyloxide vapor would be used for drying the steam and controlling the superheat and reheat of the steam, while the hot liquid would be used for preheating air and boiler-feed water and for heat storage, as desired.

In this way one can use the excess heat contained in flue gases, over what is required for preheating the air, for preheating some water.

In order to design equipment using these high-boiling compounds, the first requirement is to have the necessary thermal data available. During the past six years a considerable amount of work has been done by the members of the research staff of the Dow Chemical Company to determine and calculate the physical and thermal properties of diphenyloxide, a good part of which is summarized in Table 1. Fig. 1 gives the results of heat-transfer determinations between liquid diphenyloxide and condensing steam. The results were calculated on the basis of the external surface of the pipe as specified. Other thermal data obtained by others for diphenyl are given in the references (4, 5, 6, 7, 8, 9, 10).

Diphenyloxide is so fluid at higher temperatures that the temperature differential between the heated surface and the boiling liquid is exceedingly low.

Measurements that were made with an electrically heated iron wire while the temperature was determined by measuring its resistance while being heated, indicate that there is only a differential of 17 deg. fahr. between the $^1/_8$-in. iron wire and the boiling liquid at a rate of heat transfer of 50,000 B.t.u. per hour per square foot.

All this indicates that the heat transfer, both from the liquid and to the liquid, is reasonably high and sufficiently good to be satisfactory for commercial work.

## BOILERS ADVISED FOR DIPHENYLOXIDE

There are two types of boilers recommended for the use with diphenyloxide. The first is a boiler with natural circulation in which the only requirement is that the boiler be designed for very free circulation with a high head between the vapor-separating drum and the furnace. This makes use of the air-lift effect of the vapor as much as possible. If such a boiler is designed with a sufficiently large furnace to keep the heat transfer down to approximately 10,000 B.t.u. per square foot per hour of total surface, no trouble should be encountered. In fact, back in 1926 a boiler was operated under more severe conditions with

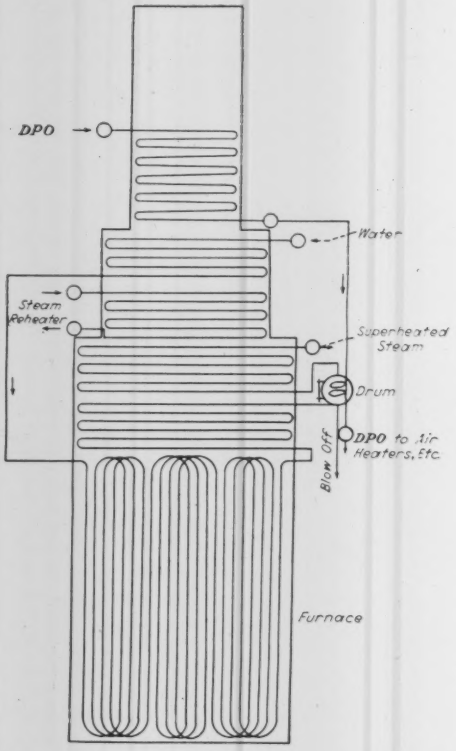


FIG. 2 SINGLE-PASS COIL BOILER

natural circulation and with perfect satisfaction. However, two tubes were plugged up at first when it was attempted to push the heat transfer to ten times the normal rating. Another time, when operation was attempted at 35 lb. pressure instead of at 125 lb., the large volume of vapor produced could not escape from the heated section fast enough. The tube became vapor bound and plugged with carbon, and it burned up. In each of these cases it was surprising to note that no large amount of diphenyloxide escaped into the furnace. Carbon formed as fast as the tubes oxidized, plugging the holes tight.

A forced-circulation boiler can be constructed to have the minimum of inventory and nothing but long tubular economizer units for heat-absorbing surfaces. The maximum amount of vapor that could ever escape from such a tube into the boiler setting can readily be taken care of by the stack, so that such a boiler can be installed almost anywhere. The design as indicated in Figs. 3 and 4 requires only that the circulating pump be coupled or interlocked with the fuel feed so

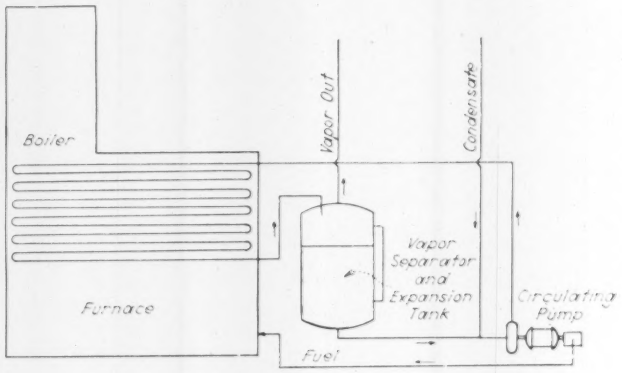


FIG. 3 INDUSTRIAL DIPHENYLOXIDE VAPOR SYSTEM

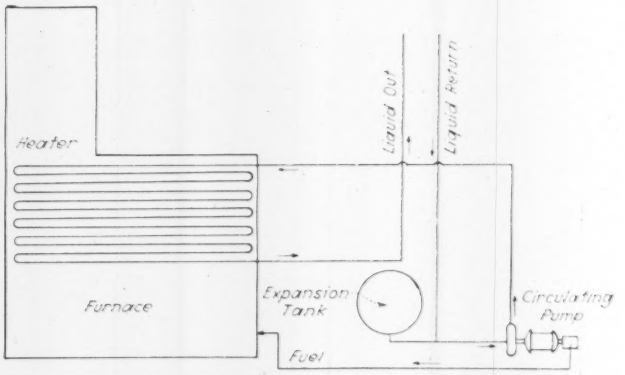


FIG. 4 INDUSTRIAL DIPHENYLOXIDE LIQUID SYSTEM

that no fuel is sent to the furnace except when the necessary circulation is obtained.

Combining the information so far obtained on these heat-transfer materials with the fact that the price of these materials has decreased continually as their use was increased, one can confidently look ahead to further progress along these lines with an ever-widening list of applications.

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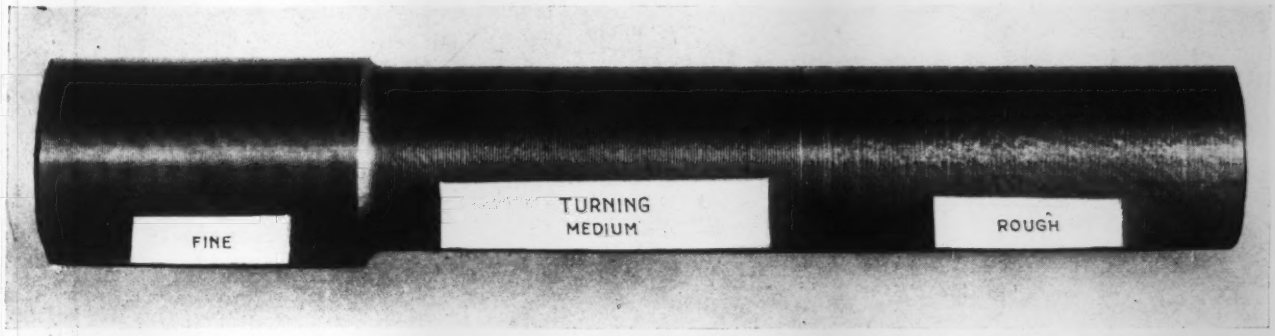



FIG. 1 TURNING FINISHES

# Standardization of Machining Finishes

## Disadvantages of Lack of Specifications Therefor—Outline of Proposed System of Specifying Type of Surface for Various Classes of Work

BY R. C. DEALE,[1] NEW YORK, N. Y.

WHILE there has been a very considerable change in drafting practice since the time when one man both designed a machine and supervised its construction, little or nothing has been done as to the specification of the quality of the machined surface on the drawing. It is believed that such specification of the quality of surface will produce manufacturing economies in all types of machine shops comparable to those that followed the introduction of tolerances.

When one man was both designer and machinist, little was necessary beyond a simple line layout giving the main dimensions of the machine or mechanism. The designer, being the machinist engaged in translating the drawing into metal, or at least being in intimate contact with that procedure, could work out the details of parts as necessary. When fits of one sort or another were called for, one part was made first, somewhere near the desired size, and the mating part fitted into it. Such methods produced machinery which operated satisfactorily, but were suitable only for equipment made in very small lots. Exceptionally skilled supervision was required, as were also workmen capable of performing several or all of the operations.

As shops grew larger, it became necessary to make the drawings clearer, putting practically all the dimensions on them. Drawings of intricate machinery when so dimensioned are difficult to follow and require very close supervision of all machining operations, as a mechanic is very apt to make mistakes in following them. In addition, the allowances for various sorts of fits must be supplied by some one, whether foreman or machinist. It is not uncommon, where such drawings are furnished a shop, for the foreman to spend a considerable portion of his time in making detail sketches of the various parts.

As a result, the more progressive shops are making complete detail drawings of all parts of a mechanism, frequently with but a single part to a sheet.

A still later development, without which modern mass production would have been impossible, has been the addition of tolerances to each dimension, so that each piece may be machined completely without reference by the mechanic to any other part. When such tolerances are properly applied, the parts may be assembled into the completed mechanism with a minimum of fitting, though it may be necessary for these tolerances to be extremely small for interchangeable assembly. Modern machinery has

FIG. 2 SHAFT-END FINISHES

[1] Management Engineer, Stevenson, Jordan, and Harrison. Mem. A.S.M.E. Mr. Deale was educated at the Rensselaer Polytechnic Institute, from which he was graduated in 1915. He was engaged in maintenance and appraisal work until the outbreak of the war. He then became an engineering officer in the U. S. Navy after a short course in marine engineering at the Naval Academy, Annapolis. After the end of the war he became connected with the Niles-Bement-Pond Co., builders of machine tools, where he eventually became assistant chief engineer and chief electrical engineer. Since 1927 he has been engaged in the installation of management methods, especially in machine shops. He has been particularly interested in securing better coordination between engineering and production departments, in the improvement in quality of drawings furnished the shop, and in various phases of standardization work.

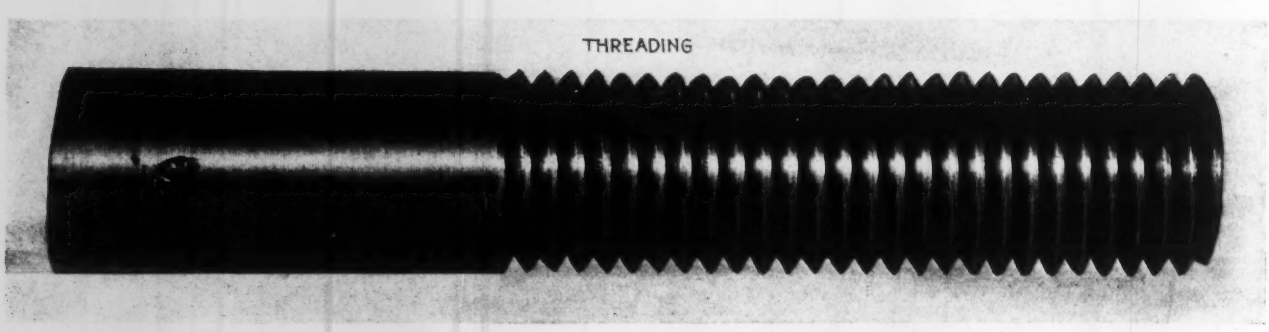



Fig. 3 Thread Cutting

Fig. 4 Grinding Finishes

made it possible to produce parts economically to almost any required degree of precision. The success of the American automotive industry is based entirely upon the use of parts machined to close tolerances, which are shown clearly on the detail drawing, and then assembled with little or no fitting into a successfully operating machine.

While complete specification of the dimensions and material of a part is becoming more and more general, few plants have done anything in regard to the specification of machining finishes. As a result there is continual friction within the plant as to just the sort of surface required. This is particularly true in plants making a large variety of parts on a jobbing basis, and these comprise the larger part of the manufacturing machine shops of the country.

### Disadvantages of Lack of Specifications for Machining Finishes

As a result of this situation, one of several things may happen, all involving a loss of time and consequently extra cost.

1 The mechanic, to prevent criticism, may machine a part all over with a high finish. As high finishes are only necessary where two parts run, slide, or are forced together, a rougher surface will be satisfactory on other portions of the part except in those cases where the finish is used for appearance only.

2 The mechanic, or foreman, may go to the designer for information as to what is necessary, or may go to the assembly floor to study the requirements of the assembled mechanism, should one be available.

3 A difference of opinion as to the sort of finish really necessary may arise between foreman and workman, or workman and inspector. This results usually in scrapped parts, although the matter may be carried

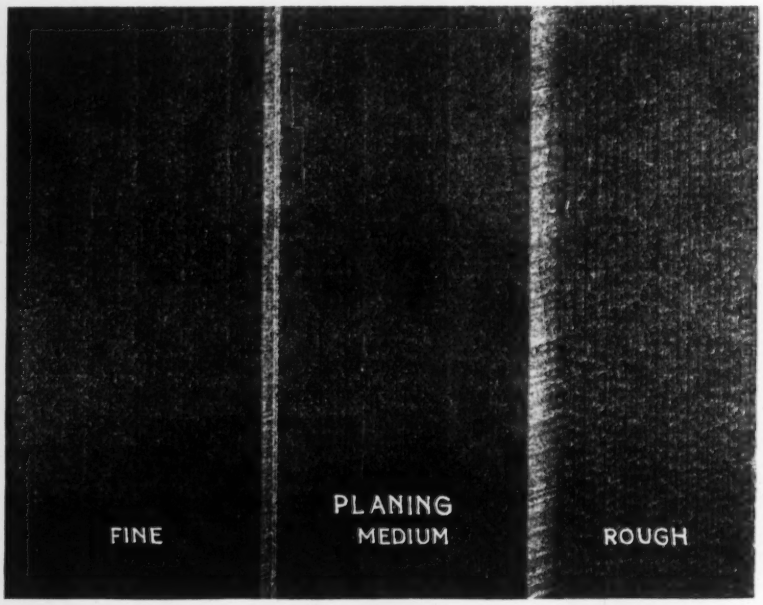



Fig. 5 Planing Finishes

on to the engineering department for final decision. In any event considerable time has been lost, and the time indirectly charged to the pieces in question has been considerably increased.

To overcome the difficulties enumerated, some form of specification of the type of surface is necessary.

Before anything can be definitely done, the engineering department, shop, and inspection department must come to an agreement as to just what types of finish are necessary, and just how each type of surface should appear.

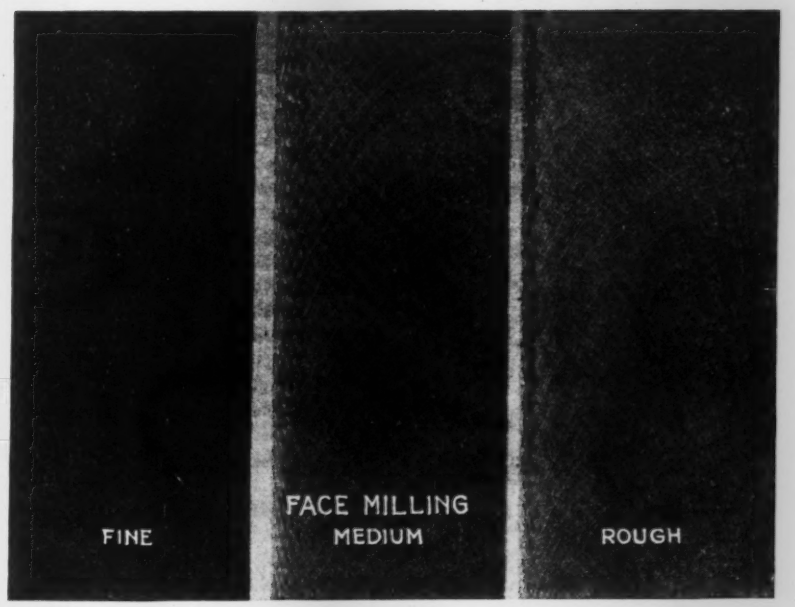



FIG. 7 FACE-MILLING FINISHES

### PROPOSED SPECIFICATION OF TYPE OF MACHINED SURFACE

The author has found that the best method of procedure is to prepare a series of samples, employing the various types of machines in use at the shop in question. These samples are discussed by the heads of the engineering, shop, and inspection departments as to their suitability for various classes of work. It has been found that three classes of finish are satisfactory for almost any work: a fine finish, a commercial finish, and a rough finish.

Figs. 1 to 11, inclusive, show such standard samples. These photographs were made at the Norton Company, Worcester, Mass., of the standard samples used in their grinding-machine division as shop standards, after extensive experiments had been conducted by them to determine just what degree of finish was required for the various parts of their machines.

These finishes are possibly somewhat higher in grade than might be required in some shops because of the extremely high grade of workmanship necessary in building grinding machines.

Fig. 3 shows a milled thread, such as might be used for lead screws and would be represented as a high finish. The grinding finishes shown in Fig. 4 do not include the mirror finishes sometimes required in rolls for aluminum foil, copper, and other soft metals.

Keyways at Norton are all high finish, as shown in Fig. 10. In a rougher class of work, a lower grade of keyways might be permissible.

In preparing the samples, feeds and speeds should be used representing ordinary shop practice, so that the finishes may be readily duplicated on commercial work. It has been found desirable to make up samples showing the following types of finish:

I—TURNING (on lathes or boring mills):
- *a* High Finish—for journals, etc.
- *b* Commercial Finish—used for press fits, bolts, portion of shafts, rough fits, etc.
- *c* Rough Finish—used where it is necessary only to remove stock for clearance, or to put part in balance.

II—THREAD CUTTING:
- *a* High Finish—for all precision screws
- *b* Commercial Finish—for bolts or for rough screws for transmitting motion at low speeds.

III—BORING:
- *a* High Finish—used for bearing or press fits
- *b* Commercial Finish—may be

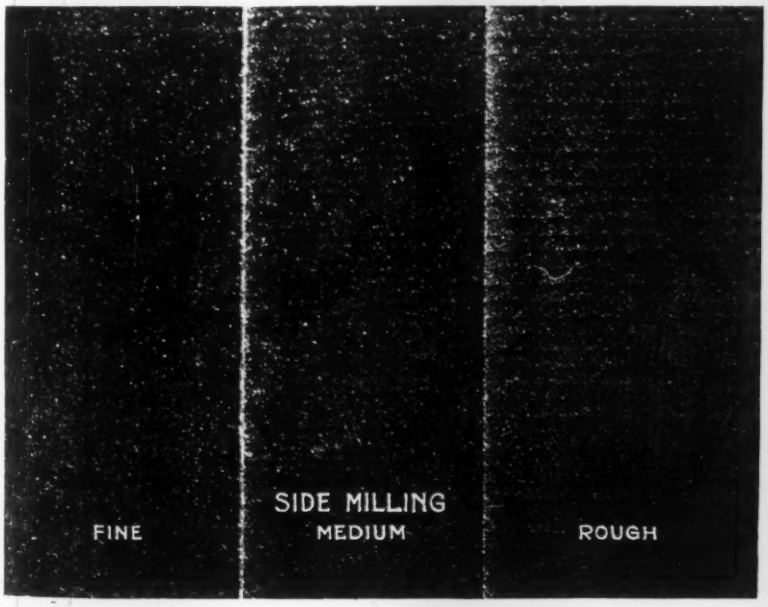



FIG. 6 SIDE-MILLING FINISHES

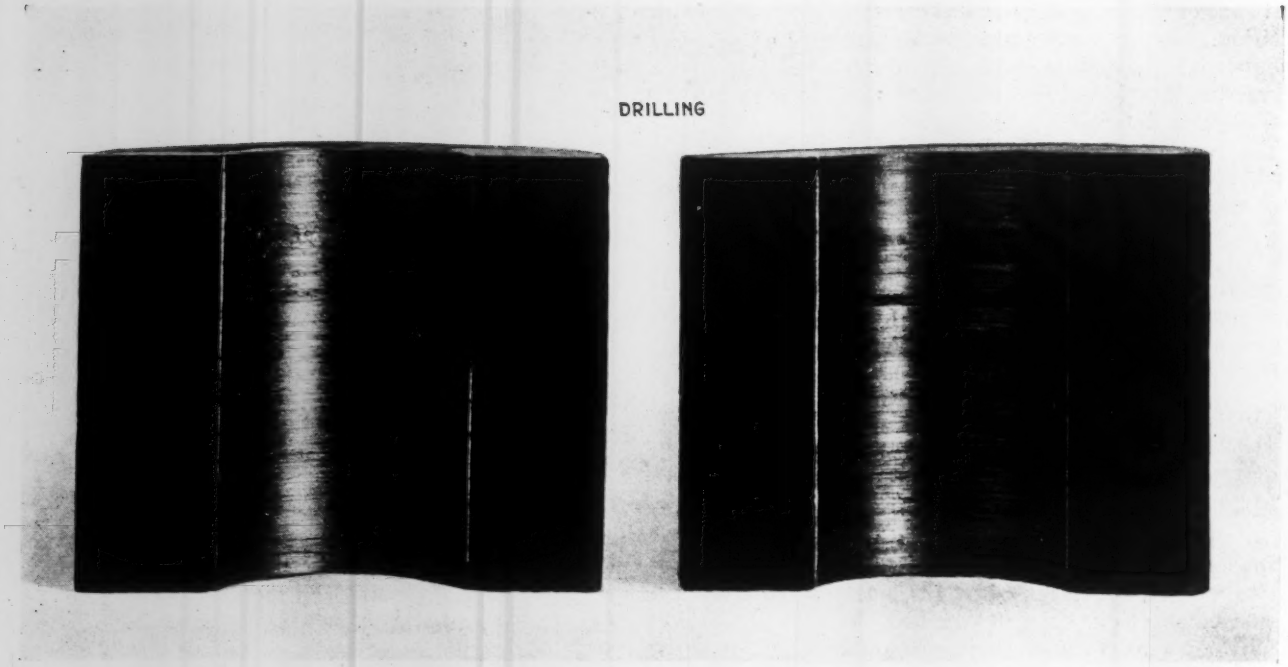



FIG. 8 DRILLED HOLES

used where mating surfaces are used only for locating purposes

*c* Rough Finish—used where stock is removed only to provide clearance or to put part into balance.

IV—GRINDING: (The mirror finishes used for rolls, etc. are not listed. Where used they should be standardized.)

*a* High Finish—used for bearings, either for rotating or sliding members

*b* Commercial Finish—used for force fits

*c* Rough Finish—usually used for truing up hardened pieces where surface is not used.

V—PLANING AND SHAPING:

*a* High Finish—used for bearing surfaces

*b* Commercial Finish—used for surfaces bolted permanently together

*c* Rough Finish—used to remove stock for clearance.

VI—SIDE MILLING:

*a* High Finish—used for bearing surfaces

*b* Commercial Finish—used for surfaces bolted permanently together

*c* Rough Finish—used to remove stock for clearance.

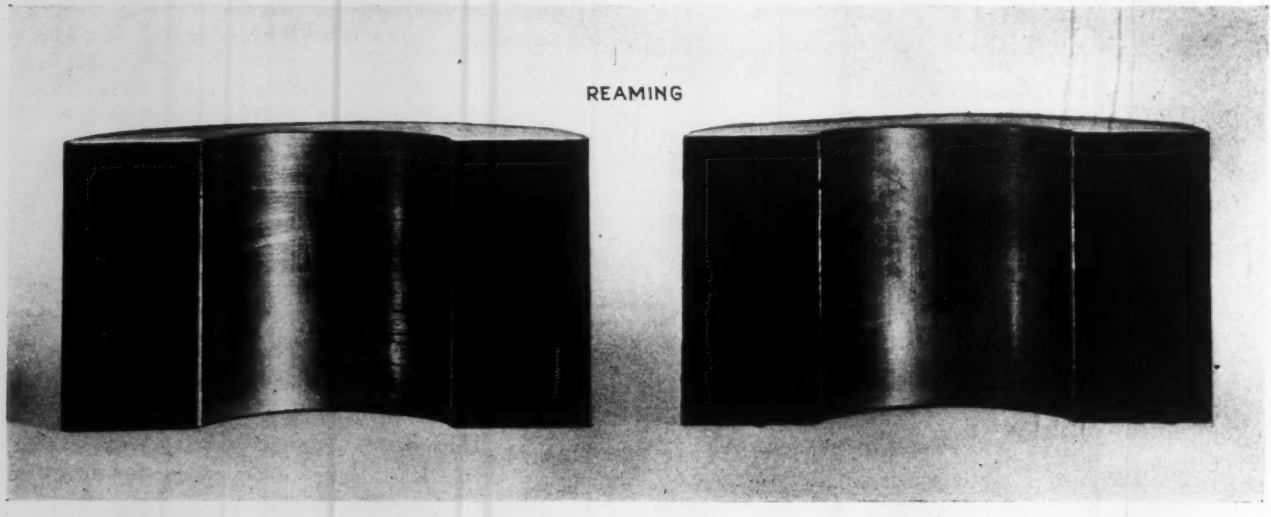



FIG. 9 REAMED HOLES

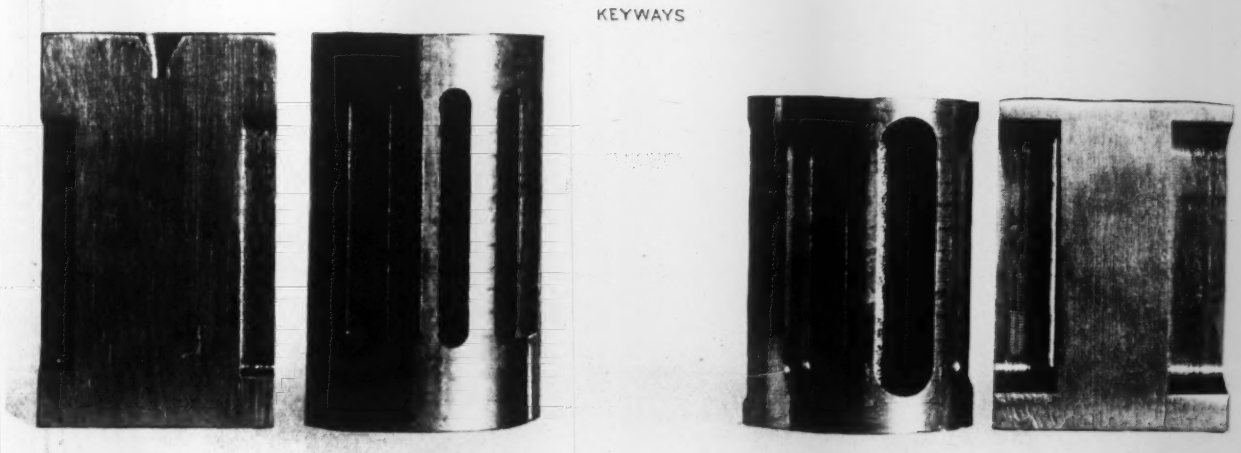



Fig. 10 Keyway Finishes

VII—Face Milling:
- *a* High Finish—used for bearing surfaces
- *b* Commercial Finish—used for surfaces bolted permanently together
- *c* Rough Finish—used to remove stock for clearance.

VIII—Drilling and Reaming:
- *a* Reamed Hole—used wherever close fit is necessary
- *b* Drilled Hole—used for clearances—as bolt holes.

IX—Keyway Cutting:
- *a* High Finish—accurately fitting key or slide key
- *b* Commercial Finish—unimportant key.

X—Polishing:
- *a* High Finish—used for appearance, as on handles and handwheels.

XI—Lapping:
- *a* High Finish
- *b* Commercial Finish.

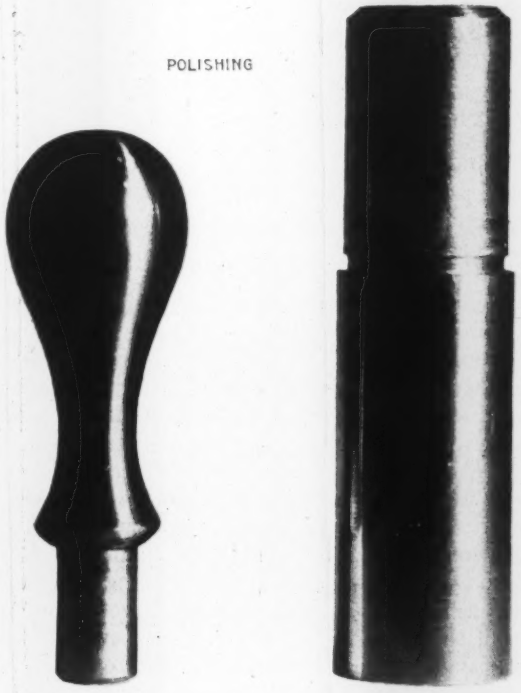



Fig. 11 Polishing

To indicate these finishes on a drawing some simple, unmistakable symbol system is necessary. Those following, which are in part those used in Germany and Sweden, seem to fill the need adequately.

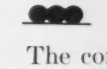
Rough Finish (any machine)


Commercial finish (any machine)

High Finish (any machine).

The rough unfinished surface of castings or forgings

Surface chipped and filed to size


Surface scraped to fit.

The connecting rod illustrated in Fig. 12 shows just how these symbols would be used on a drawing. The black circles indicate clearly those portions of the rough surface that are to be left untouched. The two faces are to have a second-class finish, presumably with a face mill, as shown in Fig. 7, the $4^{3}/_{4}$-in. round opening is to be reamed or finish-bored to a high finish, while the rectangular opening will be slotted to a commercial finish. As can be seen from this drawing, the symbols are clearer than the commonly used "*f*," and in addition give much more information without encumbering the drawing with notes.

The foregoing series have the merit of not requiring the engineering department to specify anything re-

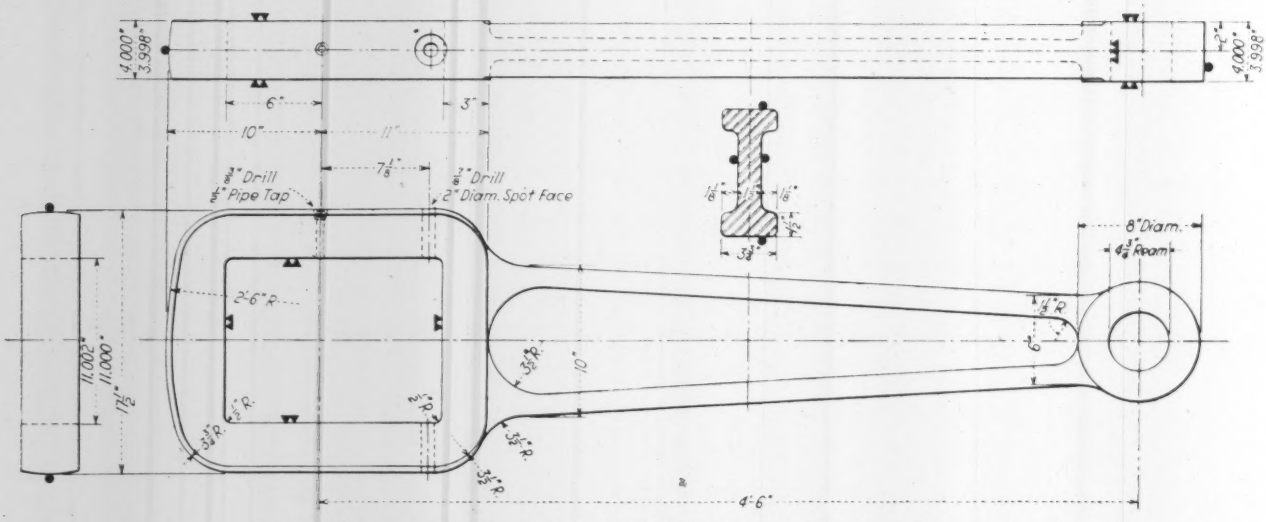



Fig. 12 Showing How Finish Symbols Are Indicated on Working Drawings

garding the machining of the surface other than its final appearance. The sixth symbol may not be universal in its application, but it will have value in many shops. These symbols require the engineering department to indicate in some other manner when a part must be ground, lapped, or polished, but otherwise the shop is left free to make a part in the way that it believes to be the most economical.

Shop and inspection departments will save much time and argument, not only by specifying the type of finish but by giving a clear idea as to just what constitutes each type of finish on a given machine. To do this it is desirable to install in each department a cabinet containing a set of samples protected against rust. In doing this the engineering and inspection departments should each have a complete set, while the machining departments should have sets covering only these surfaces they are engaged in reproducing. For example, the planer department needs only a set of planer samples.

Specifications of machining surfaces, as outlined in the preceding pages, may be set up in any shop, either small or large, at a very moderate cost, provided they go into effect at first on new parts only. It is relatively simple to change old drawings as they are used for new lots.

An extension of this idea will undoubtedly come in time in the national or international standardization of these finishes. To accomplish this, much work will be necessary. The industries of the country must agree as to what constitutes each class of finish, and must then write specifications so definite that a surface produced in any shop will be quite comparable with that produced in any other shop. This can be done by specifying the depth of tool marks, as measured by an optical comparator or some similar instrument, and also a tolerance for each class of finish.

To recapitulate, it is believed that the advantages to the average machine shop from the specification of machined surfaces would be comparable only to those resulting from the use of tolerances, which are generally conceded. In addition it will be possible to introduce such specifications much more readily, and at a much lower cost, than was the case with tolerances. Should a national standard be set up it will greatly facilitate the production of parts in a shop other than the one in which they were designed—a practice which is becoming increasingly more prevalent. A company having no shop at all may design a machine and send its drawings out to a jobbing shop where it is to be built, and one with a shop may do the same when its facilities are overcrowded. A national standard would be particularly desirable for ordnance work, which, in time of emergency, may have to be done in any shop in the country.

## A New Property of Metals

IT SEEMS evident that an important property of steel is its ability to stand occasional overstress without the development of a crack which, in subsequent service, spreads to failure.

This "crackless plasticity" of steel is not dependent upon ductility as ordinarily measured in a tension or cold-bend test. Heat-treated alloy steel has a high elongation and a high reduction of area, yet seems to be relatively low in crackless plasticity. Elongation and reduction of area and good results in the cold-bend test are measures of the ability of steel to undergo great deformation under one very severe overload.

It is not at all certain that a steel which will resist one extreme overload without fracture until a high elongation is reached will resist thousands of small overloads without starting a spreading fatigue crack when each overload causes stress above the endurance limit of the material in some localized spot. Crackless plasticity may be regarded as a sort of ductility, although not the sort determined in the ordinary tension or cold-bend test.—H. F. Moore in *The Iron Age*, Sept. 10, 1931, p. 675.

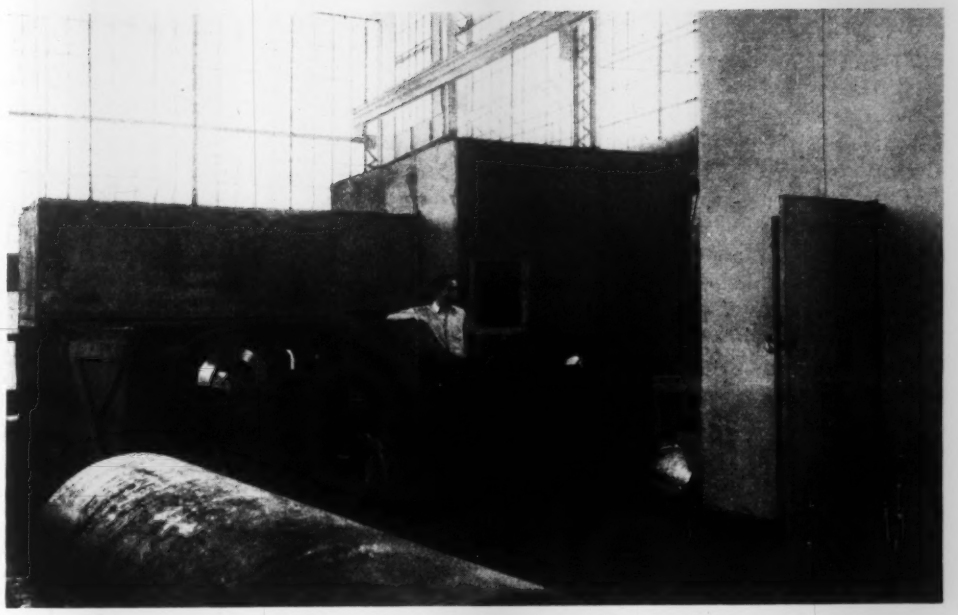


FIG. 1 X-RAY INSTALLATION FOR THE INSPECTION OF HEAVY STEEL CASTINGS

# Radiographic Inspection of Metals

## Relative Value and Applications of X-Ray and Gamma Ray Inspection of Steel Castings, Forgings, and Welded Structures

BY HERBERT R. ISENBURGER,[1] NEW YORK, N. Y.

NON-DESTRUCTIVE routine testing of structures has become of foremost industrial importance. One of the most reliable of such methods is radiographic examination, in which shadow pictures are obtained showing the interior condition of the object under investigation without destroying or in any way harming it. These pictures are made by means of a penetrating radiation of either X-rays, produced electrically by an X-ray tube, or of gamma rays, which are of shorter wave length than X-rays and are obtained from radium or its emanation. X-ray pictures are known as "exographs" as distinguished from "radiographs" made by means of gamma rays.

Fig. 1 shows an actual installation arranged for the X-ray inspection of a three-ton header for a high-pressure steam-electric power plant. The X-ray tube is placed in a lead-lined safety drum within a sheet-iron case directly over the casting. The film is placed in special cassettes on a carrier which can be seen projecting from the end of the casting. The X-rays are thus passed through the wall and make a shadow picture which shows the location and nature of any serious defects. During exposure, the casting is surrounded by a lead-covered housing to prevent the X-rays from passing out into the room. The casting and housing travel along tracks under the tube. A direct current of 230,000 volts is produced by special transformers and rectifiers within a sheet-iron room just behind the control stand. The high-potential equipment is thus completely surrounded by a grounded metal shield. On the right is the dark room for the immediate development of the films.

A diagram of the radiographic arrangement is shown in Fig. 2. The focal spot *A*, which is either the target of an X-ray tube or the bulb containing the radium, should be as small as possible in order to obtain sufficiently fine detail in the film *F*.

As with ordinary photographs, darker regions on the X-ray negative or lighter regions on the print mean that more rays have passed through the object at that point, indicating that the object is more transparent at these points.

Hence cavities in the object will show up on the print as lighter spots, whereas heavy impurities or more dense metal will appear as darker spots. The absorption of the rays grows with the atomic weight of the material examined. Because of its great atomic weight, lead is used to protect the operator, since sufficient thicknesses of lead will absorb the rays completely.

[1] Secy-Treas., St. John X-Ray Service Corporation.

Presented at a meeting of the A.S.M.E. Machine Shop Practice Division held in connection with the National Metal Congress, Boston, Mass., Sept. 22, 1931.

## APPLICATIONS TO FOUNDRY PRACTICE

There are two particular fields in the metal industry where radiography is of utmost value: foundry and welding practice. In foundry practice there are two important applications. One of these concerns the development of manufacturing technique, the other the final inspection of the finished product. Although the radiographic method seems expensive, there are many cases where the possible failure of a casting or forging would cause damage far in excess of the cost of the examination. Here radiographic inspection becomes a matter of insurance.

X-ray tests confirmed by cutting a section of the casting and by other means of examination indicate

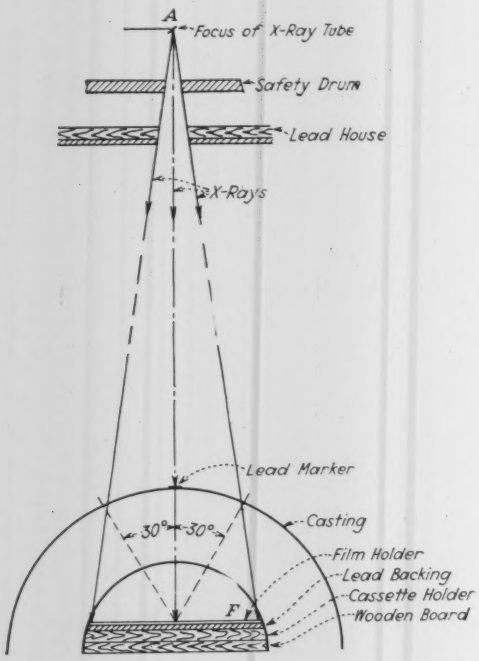



FIG. 2 DIAGRAM OF RADIOGRAPHIC EXPOSURE ARRANGEMENT

that the undesirable internal conditions in castings fall into relatively few classes, all of which are traceable to definite and simple causes. Most of these causes, if not all of them, can be eliminated by proper foundry practice. Experience shows that when defects have been corrected by making the required changes in foundry methods, they tend to stay corrected. It is thus possible, by the aid of radiography and the conclusions drawn from its results, to eliminate from 75 to 90 per cent of the more important defects in castings produced by a given foundry.

The principal undesirable conditions in steel castings revealed by radiographic examination are the following:

1 Gas, slag, and sand pockets due to loose dirt in the mold. Fig. 3 is an exograph of a part of a steel casting, $1^5/_8$ in. thick, showing a large gas pocket and sand inclusions around the chaplet.

2 Gas cavities due to imperfectly deoxidized metal. (Fig. 4.)

3 Sand inclusions due to cutting of the mold or runners. Fig. 5 shows a large sand pocket in steel $2^1/_2$ in. thick. This defect was found in one of the headers shown in Fig. 1. By a double exposure of this spot it was determined that the inclusion started close under the outer surface and did not penetrate more than one-quarter of the way through the wall; hence it caused no serious trouble.

4 Shrinkage cavities occur sometimes because the feeding is imperfect, the molten metal being fed into the casting while it solidifies. (Fig. 6.)

5 Pipe or primary shrinkage caused by failure of the risers to function as indicated. (Fig. 7.)

6 Secondary pipes caused by the flow of viscous metal through constricted channels in the casting during the final stages of solidification. (Fig. 8.)

7 Spongy metal is shown in Fig. 9. Metal occupies more volume in the liquid state than in the solid. When it solidifies, a definite cavity may be formed as in Fig. 6, or there may be a region that contains many minute cavities, i.e., spongy metal.

8 Hot tears occur frequently in cast steel because of cooling stresses set up in the metal after it has solidified but while it is still tender. Usually there is not a single crack but a system of cracks as shown in Fig. 10.

9 Shrinkage cracks starting from a sinus-like cavity developed during cooling. An exograph through the wall $1^1/_8$ in. thick and a photograph of the cross-section of this area are reproduced in Figs. 11*a* and *b*.

10 Rupture developed during pressure test. Fig. 12*a* shows a portion of a steel casting which was selected by the customer's inspector as particularly good after applying ordinary inspection tests. The exograph revealed a sharply defined crack starting from a small cavity or inclusion. Its location was marked with crayon on the outside of the casting, and it was found where indicated when the piece was sectioned. Moreover, micrographic examination of the material adjacent to the crack showed that it had been cold-worked. (Fig. 12*b*.) This casting was probably ruined in the very test that "proved it good."

The rapid development of higher-pressure and higher-temperature processes presents increasingly numerous cases where radiographic tests may be applied and where they often will be found absolutely necessary. While these conditions are perhaps more prevalent in the case of castings and welds, they also occur with forgings as well as bar or plate stock. Fig. 13 shows a deep crack in a steel forging.

## APPLICATIONS TO WELDING

The principal undesirable conditions in welding revealed by radiographic examination are the following:

1 No penetration, that is, improper fusion at scarfs between weld and parent metal
2 Laps not fused between layers of weld metal
3 Gas inclusions, more or less numerous throughout the weld zone
4 Shrinkage cracks developed during or after welding.

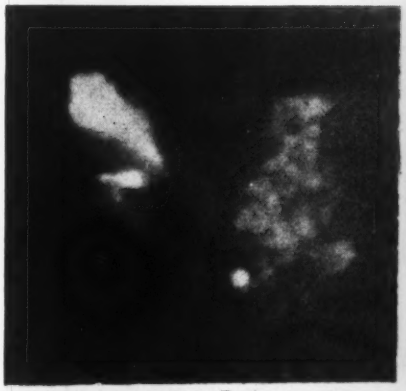


FIG. 3

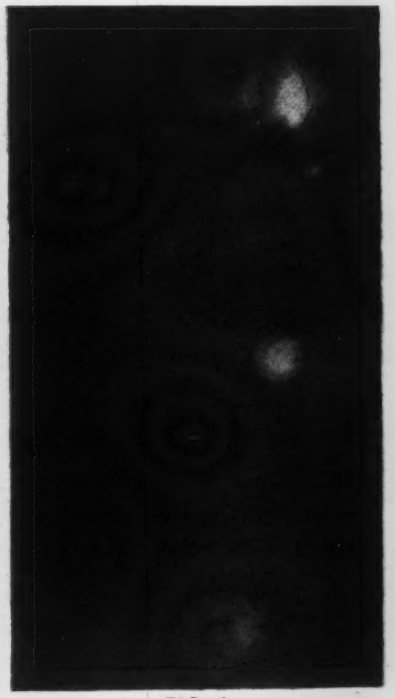


FIG. 4

FIG. 5

FIG. 6

FIG. 7

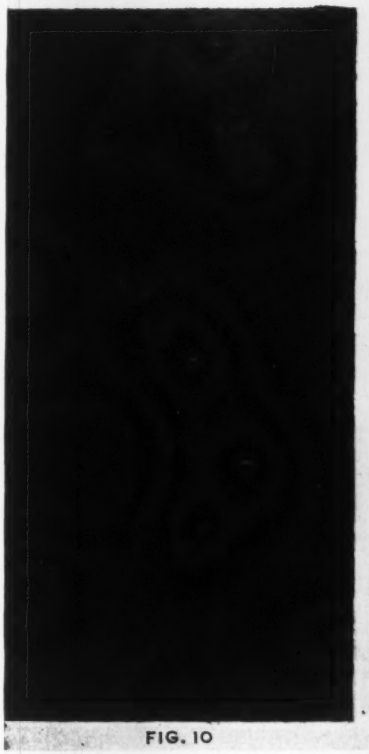


FIG. 10

FIG. 8

FIG. 9

FIG. 3 GAS POCKET AND SAND INCLUSIONS IN CAST STEEL $1^5/_8$ IN. THICK; FIG. 4 GAS POCKETS IN STEEL CASTING; FIG. 5 SAND POCKET IN $2^1/_2$-IN. CAST STEEL; FIG. 6 SHRINKAGE CAVITY IN HEAVY STEEL CASTING; FIG. 7 PRIMARY PIPE IN THE COPE SIDE OF A STEEL CASTING; FIG. 8 SECONDARY PIPE IN THE DRAG SIDE OF A STEEL CASTING; FIG. 9 SPONGY METAL IN CAST STEEL; FIG. 10 HOT TEARS IN CAST STEEL

No penetration and laps are usually characterized by slag inclusions, which may be actually slag but are mostly a fine skin of oxide. Shrinkage cracks occur very seldom.

By means of X-ray examination it was found, for instance, that a certain energy of the electric arc gave the best results for a given welding operation. If the current was greater than this, porosity in the welds began to show in the exographs; if the current was less, the X-rays revealed a lack of fusion and adhesion between the welded surfaces. In this way it was determined that a 250-amp. arc should be used for welding plate stock from $^1/_2$ in. to 1 in. thick, whereas a 500-amp. arc is necessary for $^3/_4$ in. to $1^1/_2$ in. Too long an arc causes "burning" or oxidation of the metal. The electrode metal should have a higher melting point than the parent metal, as otherwise there is a tendency to the formation of unfused areas on the parent metal.

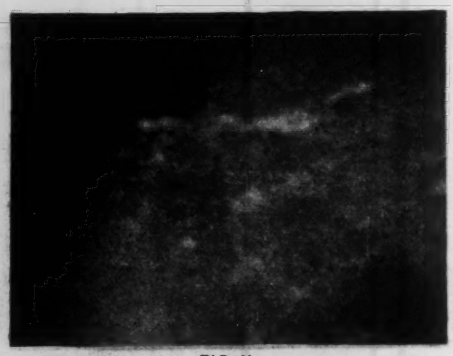


FIG. 11a

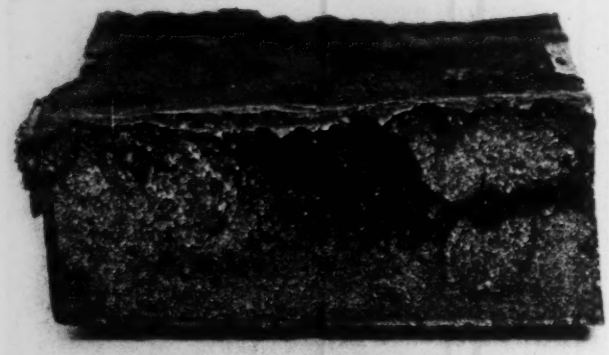


FIG. 11b

FIG. 11*a* SHRINKAGE IN CAST STEEL $1^1/_8$-IN. THICK

FIG. 11*b* PHOTOGRAPH OF CROSS-SECTION OF SPECIMEN IN FIG. 11*a*

Welding speeds used commonly with bare metallic electrodes are too high for sound work. Of course speeds that may be used vary with the type and size of the welding rod and with the nature of the plate to be welded. X-rays determined that each welding rod has an optimum set of conditions which give substantially sound joints. By X-raying each trial the right rate of feed was determined. In similar ways, X-rays helped

FIG. 12*a* COLD CRACK IN STEEL CASTING

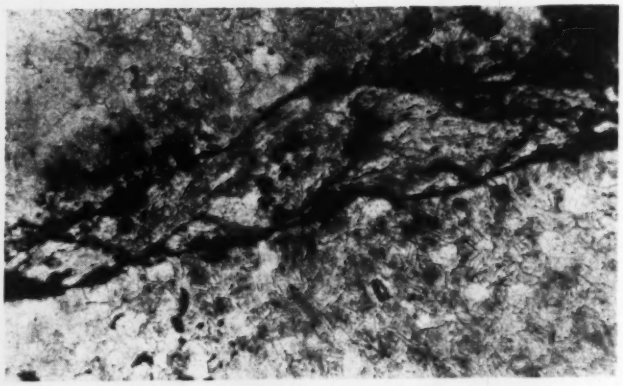


FIG. 12*b* MICROGRAPH REGION EXOGRAPHED IN FIG. 12*a*

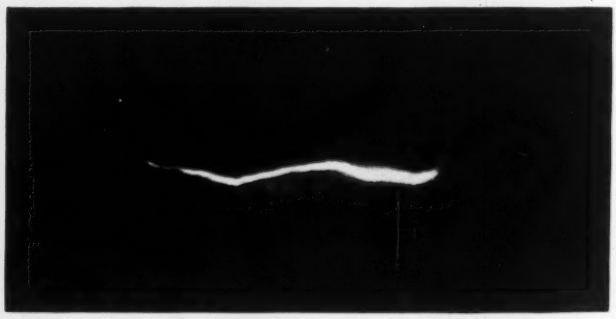


FIG. 13 DEEP CRACK IN STEEL FORGING

to select the welding rod and its size and determined the way the welder should hold the arc. The best coating and the proper amount of coating can thus be determined. Too much coating produces porous welds.

In practice, each welder should be taught to correlate his work with the X-ray evidence. He will learn more quickly in that way and remember the results and consequently use the right judgment in his future work. For each welding operation the right technique should be developed. Sample welds should be made in scrap pieces of the kind of plate to be used in construction and these should be X-rayed. Films of the preliminary welds are studied and the technique is modified accordingly. As soon as the test plates are perfect and the correct procedure is determined, production is started.

While the work is in progress, test coupons should be X-rayed at intervals. Physical tests made on such X-rayed coupons have shown that internally sound welds also have desirable strength and toughness.

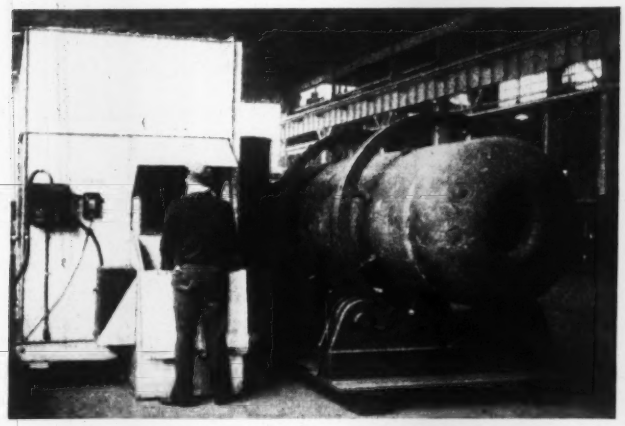


FIG. 14 X-RAY INSTALLATION FOR THE INSPECTION OF WELDED PRESSURE VESSELS IN A BOILER SHOP

More important structures like welded seams in pressure equipment for severe services should be X-rayed completely. Fig. 14 shows an installation in operation in a boiler shop for the routine inspection of welded pressure vessels. A boiler drum is set up for inspection of the girth welds. The high-tension power plant is mounted on a movable platform and surrounded by a sheet-metal housing, while the safety drum containing the X-ray tube is seen in front of the housing. The tube can be rotated about its axis and raised and lowered when desired. The control cabinet is also attached to the housing. For examination of girth seams, the vessel is rotated about its axis.

A typical exograph of a longitudinal seam is shown in Fig. 15. The weld itself is not distinguishable because the weld metal was perfectly sound. The weld zone can only be located by reference markers. In Fig. 16 slag inclusions extending along the walls of the joint are indicated as more or less cloudy elongated areas. The welded zone in this case can be readily located. Both exographs were made through $2^1/_4$ in. of steel. Gas holes, whether large or small, appear as sharply defined rounded spots as in Fig. 17, which shows a weld in $1^1/_8$-in. stock. In the exograph three regions of different density appear: Region *A* represents the plate, region *B* the built-up metal on the surface toward the X-ray tube, and region *C*, which contains the actual weld, the excess weld metal on the side facing the film.

Although this is a porous weld, it may be considered permissible for the service intended. Here lies the danger of inexpert radiographic inspection, that the picture may show an apparently bad condition which actually is permissible. In this respect X-ray examination may tend to be a rigid test, calling for skill in the interpretation of the films and a thorough knowledge of the material's ultimate use. Its results, therefore, must be studied carefully and with the aid of expert advice.

Figs. 18*a* and *b* show electric-arc-welded test plates of $^5/_8$-in. stock made by the same welder. The material is an alloy steel and the weld is V-shaped, welded from one side as is the practice in welding small tubing. Exograph (*a*) shows the joint as originally submitted for X-ray test. The welder, after study of the X-ray evidence, changed his technique as previously described, and in his fifth plate was able to turn out a perfect weld as reproduced in Fig. 18*b*.

Alloy-steel tubing is now widely used in superheaters, oil crackeries, and various other severe services. On larger tubing and on welded pipes the films are placed inside, behind the welded seams. The exposure technique for routine inspection of circumferential welds in tubing of small diameter is schematically shown in Fig. 19. Fig. 20 shows the three exposures on one film showing the complete weld in a pipe 2 in. outside diameter which was thermit-welded. The dark areas

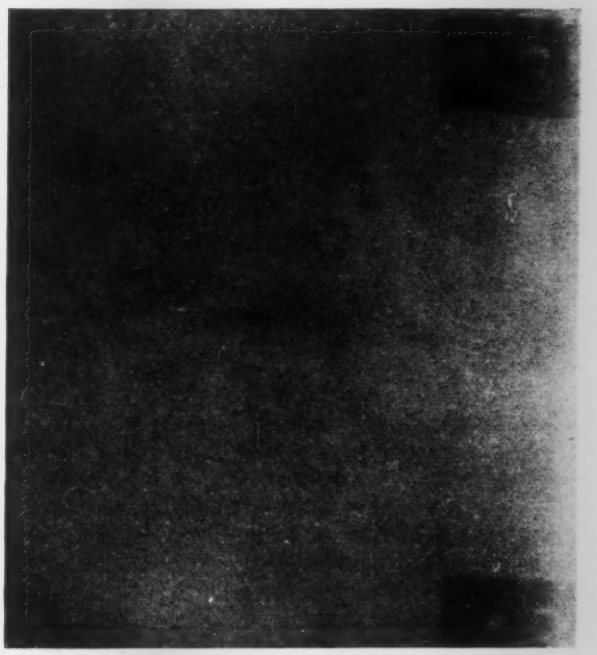


FIG. 15 EXOGRAPH OF LONGITUDINAL SEAM, SOUND WELD

in the exograph indicate the more dense and excess weld metal.

## TIMING THE EXPOSURE

Fig. 21 is an exposure chart which has been evolved for X-raying various thicknesses of steel at the peak voltage at which present tubes will work. This curve makes it possible to visualize the exposure conditions under which all the work described in this paper was performed. The thickness of the material is plotted against the exposure time in minutes. Operation is at 230,000 volts and 4 milliamperes (18-in. spark gap) with 24-in-focus film distance. The area of the material

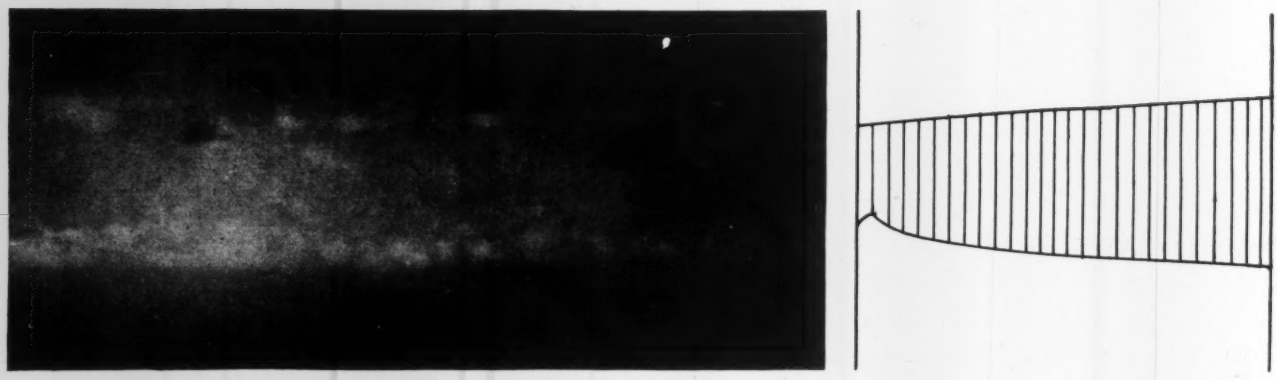


FIG. 16 EXOGRAPH OF WELD CONTAINING SLAG INCLUSION, 2½-IN. PLATE STOCK

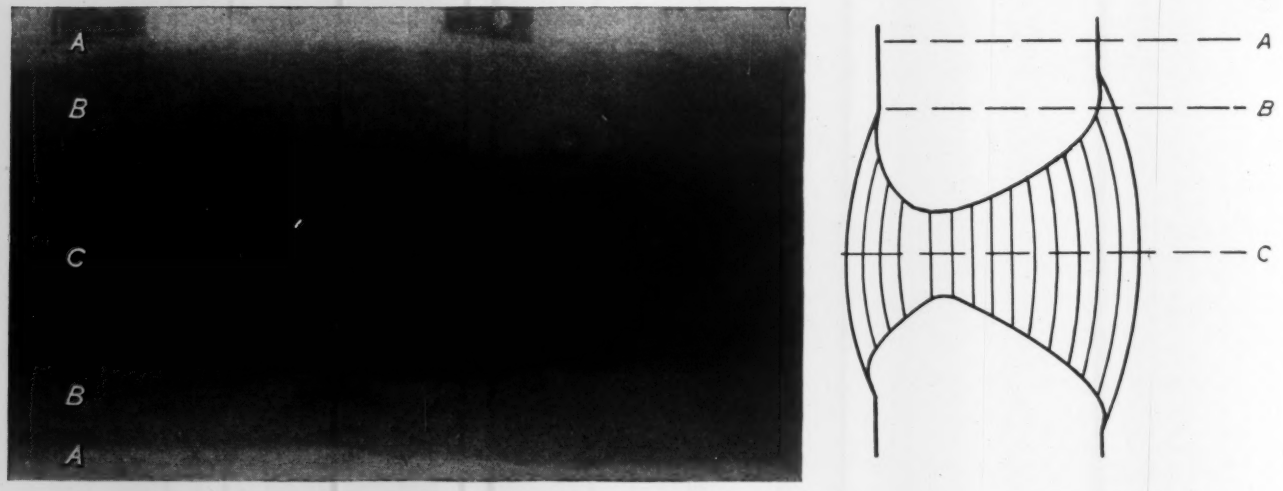



FIG. 17 POROUS WELD THROUGH 1⅛-IN. PLATE

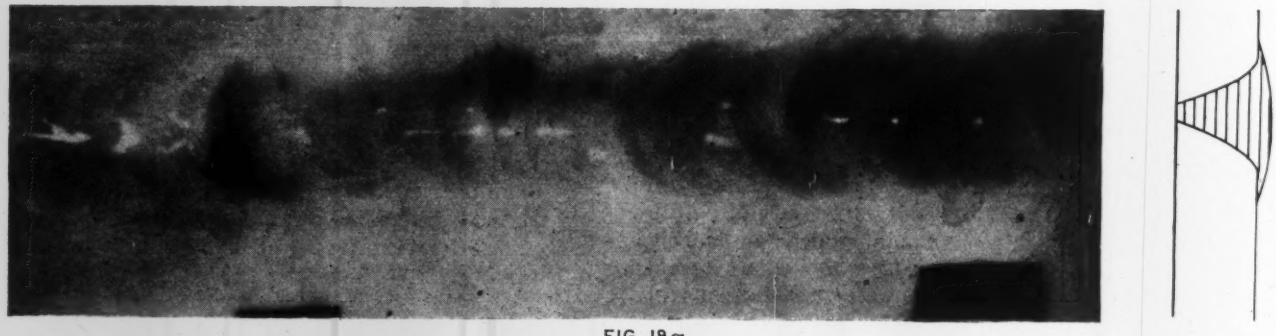


FIG. 18a

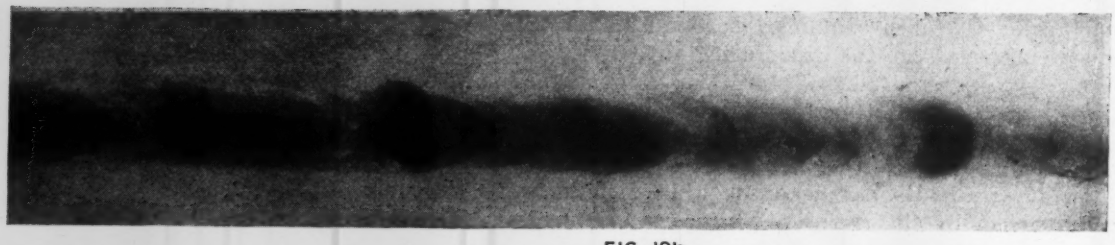


FIG. 18b

FIG. 18a BAD WELD IN ALLOY-STEEL PLATE, ⅝-IN. THICK; FIG. 18b IMPROVED WELD SIMILAR TO THAT OF FIG. 18a MADE AFTER STUDY OF X-RAY EVIDENCE

covered is 12 in. square. Buck film is used between Westex intensifying screens. It is a matter of simple arithmetic to determine the variation in the photographic effect caused by changing any of the factors involved: namely, the voltage, distance, current, and time. Since the intensity varies inversely as the square of the distance, the relation of exposure times would be directly as the square of the distance.

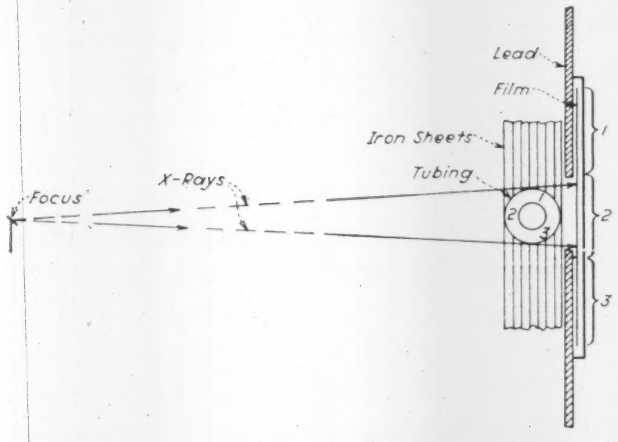



FIG. 19 RADIOGRAPHIC ARRANGEMENT FOR INSPECTION OF TUBES OF SMALL DIAMETER

X-rays should be employed whenever advisable on steel castings and forgings having a thickness of 3 in. and less; whereas gamma rays should be used for examination of heavier material; 10 in. of steel has been successfully penetrated thus far. For radiographic inspection of welded seams, X-rays should be used whenever possible, since this kind of radiation gives more detail in the picture than do gamma rays. The appearance of the various defects is almost the same whether in castings or welded seams, but the precision in X-ray inspection can be raised up to 1 per cent in 3-in. stock and less, but to not better than 3 per cent in gamma-ray examination. This holds good for blowholes which lie in the direction of the rays.

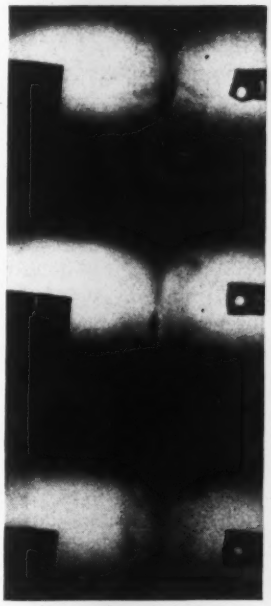


FIG. 20 EXOGRAPH OF THERMIT WELD IN A 2-IN. PIPE

## Cost

The costs for suitable X-ray installations and for their operation depend a great deal on the material to be examined, its thickness, conditions, and mobility. A conservative estimate of operating cost is $3 to $5 per hour, depending on the way the equipment is written off. The cost of radiographic inspection by means of gamma rays is difficult to estimate. The radioactive material can be rented and in most cases the expense for such work equals the cost when X-rays are used. In certain cases it is easier to bring the radium to the job than X-ray equipment, although the thickness of the material may be within the X-ray limits. X-rays should, however, be employed whenever possible, since they produce better contrast and more details in a much shorter exposure time.

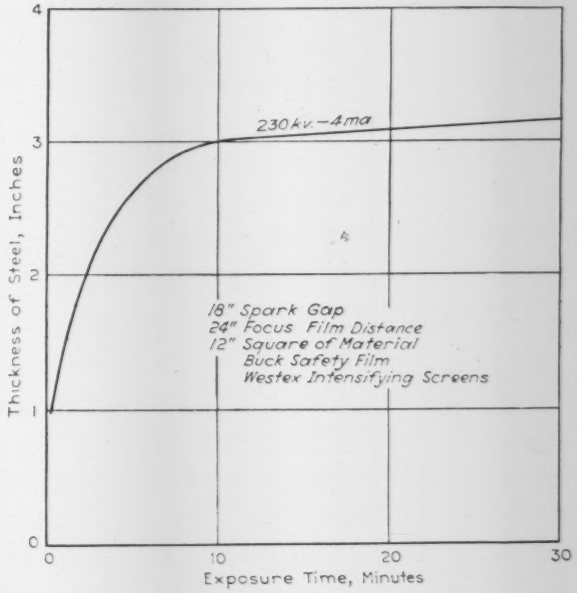



FIG. 21 EXPOSURE CHART FOR X-RAYING STEEL

## The Beginnings of Science

TRACING the records of science backward, we see its varied branches dwindling to two, namely, medicine and mathematics. The earliest of all complete scientific treatises that have come down to us are those in the medical class. Sections of the so-called Hippocratic Collections may well date back to the sixth or seventh century, B.C. With the aid of the Iliad, scientific tradition among the Greeks can be traced back to the ninth and tenth century B.C., and the Ebers Papyrus and the Edwin Smith Papyrus of Egypt take us back still farther. In the mathematics class, there are the Rhind Papyrus and the very recently discovered Moscow Papyrus. The former professes to be a "guide for calculation," and in it is found the measure of a circle from which a value of $\pi$ as 3.16 can be deduced. The Moscow Papyrus is the oldest of them all. Its contents include the determination of the volume of a truncated pyramid and the area of a hemisphere. Whether the determinations were based on general formulas, or were empirically obtained, remains to be proved. If the former, it will be necessary to rewrite the history of ancient science.—Dr. C. Singer before the Second International Congress of the History of Science and Technology, London, June 29, 1931.

# Modern Developments in Textile Machinery

IN A PAPER dealing with modern textile machinery, presented at the Hartford meeting of the A.S.M.E., and published in abridged form in the June issue of MECHANICAL ENGINEERING, Albert Palmer pointed out that, among other things, the product of gingham looms had virtually been displaced by other fabrics in the manufacture of which such looms were practically useless. The result was that the mills which had been engaged in weaving ginghams either had reorganized their methods and equipment or had gone out of business. The introduction of standardized looms producing a wide variety of fabrics and developed as a result of cost analyses, had saved 34 per cent in the cost of weaving, reduced second-quality yardage 50 per cent, and increased output per loom 11 per cent over that of old single-fabric machines.

In the discussion which ensued, J. McElroy, superintendent, Maverick Mills, Boston, Mass., gave instances where savings of 45 per cent in direct labor with 6 per cent increased production had resulted. The improvement was due to better running of work. Mills must solve yarn problems before faster and more efficient assembly machines can be used. Increased production from present looms should be sought first. As the number of looms per weaver increases it will be found that a limit is reached due to the time consumed in walking from one loom to another. A faster loom will be successful only with improved yarn, as the stops per hour must not be increased. Mills operating at 75 per cent efficiency and running but a small number of looms per weaver do not need new looms to increase efficiency and reduce costs, since mills on similar goods run twice as many looms at 90 per cent efficiency.

### Cooperation of Builder and User Necessary

Stephen C. Hale, manager of Auxiliary Division, Cheney Brothers Manufacturing Company, thought that it was doubtful if the gingham industry would have been benefited by the use of looms of universal construction at the added cost. This industry, which had enjoyed 60 years of active life, he said, seemed to have justified use of the type of machine as built. Use of time studies and engineering analyses as given by the author would require complete cooperation between the builder and user of the machinery. The time had arrived when textile-mill operators could reduce the size of their machine shops due to developments made in textile machinery by manufacturers and their departing from long-established traditional methods. Continued cooperation of the industry, he believed, would contribute to the solution of many of its problems.

### Many Changes in Carpet-Weaving Industry

Within the last few years many establishments had been regrouped to improve manufacturing costs and styling, to increase production, and to meet modern competitive conditions, said E. Wadsworth Stone, research and consulting engineer for the Bigelow-Hartford Carpet Company. He stressed the value of cooperation between manufacturers and users to encourage new developments. Benefits to be derived from research and comprehensive engineering work, he said, were not confined to the manufacture and use of new equipment. They applied to the acquisition of raw materials, their selection for the particular purpose in mind, and their fabrication to suit existing or new equipment, to secure a low-cost quality product for quick delivery.

Study and analysis of weaving processes in the mill with which Mr. Stone is connected had reduced the total average time lost in weaving operations as much as 50 per cent on some grades. A periodic check was made between performance and established standards. The ratio of actual to established cost was a measure of performance. If this equaled the standard, the rating was 100; if over 100, it indicated excess cost; and if lower, a manufacturing profit.

The lost time based on 100 yards of production had decreased greatly, and the yardage produced per net loom-hour operated had improved in spite of an increased tendency toward wide widths of fabric and the consequent lower rate of production. This saving, Mr. Stone said, was entirely apart from that gained by the speeding up or remodeling of existing machinery, or its replacement with more modern units. Improvements in weave rooms had been paralleled with similar improvements in the preparation of raw materials, power generation, and a better coordination of the entire plant personnel and equipment.

Standardization of domestic rug sizes and the consumer's preference for seamless fabrics had brought about changes in weaving equipment from that suitable for 27-in. or 36-in. goods to widths of 18 ft. or more, and woven in rolls of from 30 to 40 yd. in length. This demand had required equipment weighing upward of 50 tons per unit in contrast to looms of a few thousand pounds weight. They included special foundations, considerable floor space, dual motor drive, modern electrical control mechanisms, lubrication systems, roller bearings, alloy steels, and many other features not previously associated with weaving machinery.

Loom speed, while important, was but one portion of the answer. Raw materials should be prepared so as to permit increased speed of operation. Modification of certain assemblies often facilitated speeding up the loom, only to reveal the fact that other assemblies were weak in design and construction, or that the fabric or raw materials limited speed. There appeared to be an economical balance between perfect yardage, speed, and total cost, including repairs and maintenance.

# Engineering and Modern Culture

## A German Point of View on the Merging of Science and Engineering With Metaphysics

IN AN address before the Verein Deutscher Ingenieure on the occasion of the fiftieth anniversary of its Karlsruhe section, printed in full in the V.D.I. *Zeitschrift* of May 23, 1931, Prof. R. Plank raised the question as to whether engineering was conducive to the promotion of our entire cultural structure or at least could be made so. Because of the significance of the views expressed in Professor Plank's address, a brief summary of its main points has been prepared and is given below for the benefit of readers of MECHANICAL ENGINEERING.

### Is the Rationalism of Engineering a One-Sided Point of View?

The development of engineering in the fifty years under review has been amazing. Its victorious forward march has often created an impression that its dominance is boundless, and that the natural sciences which lie at the basis of engineering will solve all the world's problems. Physicists, chemists, and engineers have thus become exponents of a view of life that has been called "mechanism," rationalism, or materialism: systems of philosophy whose most radical adherents have claimed that everything in the world has a material structure, and that such things as thoughts, feelings, and desires are nothing more than the motions of atoms in the brain.

Without deprecating progress in natural sciences and engineering during the past fifty years, one may ask whether this progress has not had certain dark aspects and whether a one-sided consideration of it may not have led to a spiritual isolation in which, without doubt, many engineers find themselves today. One of the questions considered here is whether this one-sided point of view held by many engineers is necessarily due to an occupation with engineering problems or whether it is merely a result of an artificial and harmful separation of technical from general cultural values as developed by the rest of mankind. To answer this question it is necessary to investigate whether the dualism between the natural and spiritual sciences must prevail for all time, or whether we are not already beginning to see symptoms of the possible fusion of the two into a higher unity.

In pre-scientific times men considered nature and life, body and soul, in their entirety. The development of scientific investigation provided a necessary analysis into simple processes susceptible of primitive recognition and experimentation as well as a need for an explanation of causes. The beginnings of all sciences have necessarily been of an analytical nature. The individual branches of science have developed along this line and have thus reached a high stage. Science would, however, have remained undeveloped if it had considered this condition as being the final one. The period of analysis or segregation must be followed by a period of synthesis, leading to a scientifically enlightened totality.

### Natural and Spiritual Sciences Are Not Sharply Defined

In western Europe the division of the sciences into natural and spiritual is expressed by the terms "science" and "letters." By science is understood primarily natural science, all the rest being letters. It is, however, extremely difficult to point to the line separating the two, as is best illustrated by the case of mathematics. In its purest form the theory of numbers has as yet found no practical application and occupies therefore a position close to that of the spiritual sciences. Actually, however, it has been applied exclusively in the field of the exact natural sciences. Kant thought that "in any natural science the only true knowledge that can be found is that which can be expressed mathematically." David Hilbert considered all geometry as merely a branch of physics, and this is made all the more evident in Einstein's gravitational theory where it is stated: "Geometry is only that part of the aggregate of physical concepts which represents the possible spatial relationships of rigid bodies with respect to each other in the world of actual things."

Even logic, which not so long ago would have been unhesitatingly classified as a spiritual science, has recently been enriched by the addition of a general method for the theoretical consideration of scientific problems—the axiomatic method—developed primarily by mathematicians with David Hilbert as the leader.

These and other examples, including that of biology, would indicate that nowadays there is no sharp differentiation between natural and spiritual sciences. Any effort to segregate them is baseless and harmful; rather should one strive to find as many as possible points of contact between the two groups, thus bringing about cooperation between them. At the same time, it would be premature to try to coordinate all the sciences, natural and spiritual, in the one structure of philosophy, which has sometimes been called the "science of sciences." Our present problem is not so much to try to fit all the branches of knowledge into one system where each might possibly be represented in a fragmentary, and at times misleading, manner, as it is to try to handle each individual science in such a way that it will not stand alone, but in harmonious contact with every contiguous field of knowledge.

### The Pyramid of the Sciences

We know now what to do; the next question is how to do it. Wilhelm Ostwald conceived the sciences as forming a pyramid, with logic and mathematics as the base, the energetic sciences—i.e., mechanics, physics, and

chemistry—as the body, and with the sciences of life processes—biology, psychology, and sociology—as the apex. To prehistoric man the entire pyramid was concealed in a fog of ignorance. As time went on, the objective method of thinking spread more and more to the sciences of life processes, while lately even the doctrine at the apex of the Ostwald pyramid—sociology—has been invaded by the spirit of natural-science methods, as illustrated by Otto Neurath's recent book, "Empirische Soziologie." Incidentally, Neurath considers the distinction between spiritual and natural sciences as a product of metaphysics, and disregards as meaningless all such concepts as "spirit of the times," "spiritual processes," etc.

### Concept of a Single Science

This brings us to the concept of a single science. If it were to be believed that in this way everything comes down to physics, the term "physicalism" might be used. This would emphasize the physical nature of the single science, leaving open the manner of physical working. Thus it is immaterial whether the existence of atoms which admit of an exact definition in time and space is assumed or whether, as is done in wave mechanics, it is assumed that these atoms are replaced by couplings of space and velocity dispersions. "The important thing is that physics should be carried on in only one way." The single science deals with material concepts only or with matters in time and space, and therefore consists exclusively of materialistic bodies. Obviously, such physicalism is opposed to every kind of metaphysics, "no matter whether the latter appears as one of the subsidiary branches of philosophy or hides itself behind the mask of science." Neurath, from whose work the above passages are quoted, sets the new physicalism in the place formerly occupied by the magic of primitive peoples "which likewise embraced the entire life, followed by the separation of theology and engineering which took place in the intermediary period between primitive history and our own time."

### Leaning of the Spiritual Sciences Toward the Methods of the Natural Sciences

Plank expresses the opinion that never has there been such a radical and unconditional swing from the side of spiritual sciences toward materialism and methods of research of the exact natural sciences as now. It might be thought that this signifies a decided victory for the point of view of the natural sciences and a promise that the present dualism will shortly resolve itself into a single truly scientific concept. However, while Neurath's way of thinking is extremely logical, it is also tremendously one-sided; and, like all extremists, he is going too far.

It is extremely significant that this leaning of the spiritual sciences toward the methods of natural sciences is occurring at a time when physics itself is going through a process of transformation threatening its character of single-minded objectivity, and apparently expanding its domain of investigation up to the limits of metaphysics. Plank proceeds therefore to an elucidation of the present tendencies of modern physics.

### Tendencies in Modern Physics: The Failure of the Experimental Method

He considers the following the foremost idea of modern physics. Up to the beginning of the present century, there was only one objective physics for all physicists. This does not mean that the theories of physics were even then immutable. Newton's corpuscular theory of light had been supplanted by Fresnel's wave theory, which in turn gave way before Maxwell's electromagnetic theory. The changes, however, took place rapidly after a brief discussion and with the complete recognition by all physicists of standing; and this happened as soon as experiment, the final judge, gave its verdict. On the other hand, the newest theories of physics have entered a region lying on the border line of experimental possibilities with respect to both the infinitely small and the infinitely large. Experiment, the former supreme judge, rules no more, and the door is wide open to subjective opinions. New theories, which to some physicists of the highest standing appear as elementary and established truths, are rejected as groundless by others equally eminent. A good example of this is Einstein's theory of relativity, about which H. Thierring says that nowadays "diametrically opposite opinions are held by leading men not only in the field of politics but also in that of the so-called exact sciences."

### Doubting the Law of Causality

The law of cause and effect, which has hitherto stood as the foundation rock of exact scientific thinking, is now being subjected to critical investigation. According to Schlick, by means of the law of cause and effect, it is possible to predict happenings; and the idea of causality is closely connected with that of the universality of an order of things governed by proper laws and the necessity for various processes to occur in a certain predetermined manner.

But are all natural processes strictly predetermined? The results of the most recent investigations in the field of theoretical physics permit justifiable doubts as to unlimited predetermination. Thus, for example, the Einstein theory gave up the possibility of establishing the simultaneity of two occurrences with unlimited precision, although the uncertainty of such an objective determination of the simultaneity of the occurrences taking place within the entire confines of our solar system is a matter of only two seconds. And when, in the Bohr model of the atom, an electron jumps from one path to another it is a matter of pure accident for which no cause seems to be available. In the quantum theory exact predictions of conduct cannot be made because it is impossible to refer with completeness the beginning of a system to any definite point in time, and because it is impossible to determine with any desired degree of precision the locus and velocity of a given particle.

### PHYSICALISM IS INADEQUATE TODAY: PURPOSES, NOT CAUSES, ARE IMPORTANT

The physics of today has extended its range far beyond what the adherents of physicalism consider possible. The deliberate laying aside of reliance on direct observation which characterizes modern atomic physics, but which became apparent even earlier in the four-dimensional time-space world of Minkowski and Einstein, must be considered as a step into the realm of metaphysics. Max Plank deals with positivism, the real external world, and freedom of the will; he believes, however, that positivism provides a well-grounded but excessively narrow foundation if it is to carry the entire structure of modern science. To do that we must accept the existence of a real external world which, nevertheless, cannot be recognized directly, i.e., without some suitable hypothesis such as the law of causality. It is such hypotheses that make up the so-called physicalistic image of the world, giving a picture of the connection of the real world with the world of sensual perceptions. Here concepts of spiritual life and knowledge of nature begin to interpenetrate and to prepare for the synthesis of sciences on a foundation of parity.

The purpose of causal relationship comes next under consideration. According to Schlick, the law of cause and effect can be neither right nor wrong but only useful or useless, as it merely sets up a way to search for regularity and to describe phenomena in terms of laws. This, however, brings us into the realm of vitalism, which replaces, in matters of life, the causal explanation by the teleological one; that is, it goes back, not to causes, but to purposes. The conclusion to which Plank comes is that it is best for physics to get rid of physicalism, Neurath's dream, and to go forward with its investigations right into the metaphysical domain.

Eberhardt Zschimmer and Friedrich Dessauer saw the substance of technology in the creation of desirable values, which introduces the teleological principle. Technology is largely based on the exact natural sciences, but is not limited to their application. Like all applied sciences, it is in close contact with life and reality. The factor Man, which causal physics does not consider at all, is prominent here. Hence the exact sciences provide technology merely with foundations for models or idealized images, while the actual embodiment of the ideas, the creative work of the designer or inventor, is not to be found in books on physics. To Plank it seems that a purely causal method of considering a problem is never the mark of a prominent engineer, as the latter must be prepared at all times to adapt himself, to compromise, to make use of given conditions, and to bear in mind the economic situation, in order to achieve his purpose in actual life.

### UNFRIENDLY ATTITUDE TOWARD METAPHYSICS IS ANTIQUATED

Plank considers as antiquated the unfriendly attitude of many, if not all, engineers and scientists toward metaphysics, because, in the first place, physics has already invaded the domain of metaphysics, and next, because metaphysics has been undergoing certain changes, which makes it easier for scientists to put up with it. This is best shown by the work of Erich Becher, who, contrary to formerly prevailing opinions, holds that "metaphysics investigates the facts lying beyond the limits of experience in their connection with those within the bounds of experience." Metaphysics, in his opinion, "strives to obtain a world conception, a knowledge of the structure and composition of the entire reality, its inner meaning and basic origin, its evolution and purpose, and its value or significance." Metaphysics may therefore use the empirico-inductive method, but can also make use of ideal judgments, such as mathematical auxiliaries, deductive conclusions, and hypotheses, all of these being methods which are also employed in natural sciences. Becher therefore comes to the conclusion that the ultimate foundations of knowledge are the same in metaphysics as in the natural sciences, and that therefore the two are closely allied. Plank says that what inspires in him respect toward this realistic metaphysics is that high degree of recognition which, unlike some other branches of philosophy, it accords the natural sciences.

### MATHEMATICAL AUXILIARIES AND SCIENCES

A further clarification of the present position and future prospects is brought about by the consideration of the state of the use of mathematical auxiliaries in sciences. The change or multiplication of their use reflects the changes in the sciences themselves and the unification of their working methods; as mathematics, according to Hilbert, is "the instrument which provides a link between theory and practice, thinking and observation."

Among the "exact" natural sciences with their strongly causal arrangement, Plank places the infinitesimal calculus and the concept of the mathematical function. From the basis of hypothesis or observation, mutually dependent magnitudes are connected by means of differential equations, and the integration of these equations determines the laws connecting these magnitudes. Uniformity of application is claimed for such laws, and it is said that conclusions drawn from these laws are both necessary and certain. Certain limitations are imperative, as the slightest observed deviation from any such a law forces us either to abandon the law completely or to limit it to an "ideal" state invented for this particular purpose but not existing in reality. Thus we talk about equations of state of "ideal" gases or of laws of flow of "ideal" liquids. As long as a magnitude is investigated as a function of only one or a few independent variables, the causal connections can still be observed. If, however, the number of variables is very large, then their observation becomes exceedingly difficult because of the fact that the individual influences superimpose on each other in an uncontrollable manner. The farther away one gets from simplified theoretical ideal cases and the closer he comes in contact with actual processes, the less chance there is of being able to produce an exact conception and causal connection.

This is found to be the case in many problems of engineering, and still more so in the field of biology or of sociology. E. Becher correctly states that the inferior exactness of biology is due not to the presence of special "vital" factors but to the enormous complexity of organic processes. For the same reason metaphysics must be materially more indefinite and uncertain than the single science.

### Statistical Method Adaptable to Natural and Spiritual Sciences Alike

Side by side with the causal method is the statistical method, which is entirely different in character. Its mathematical weapon is the theory of probability. It is significant that from the start this method was used not only in natural but also in spiritual sciences, as indicated by many quotations in the original paper. Plank considers in detail how to apply the statistical method and its use in spiritual sciences. The extraordinary applicability of statistical considerations to actuality became particularly prominent with the most recent developments in theoretical physics, such as the theory of quanta. In "classical statistical mechanics" the individual molecules or atoms are entirely independent of each other. While they move without obeying any rules, the motion of each individual particle is subject to strict mechanical laws. Determinism is therefore still preserved in the microcosm. The kinetic energy is equally distributed among all degrees of freedom of the system under consideration, i.e., in the progressive, rotary, and intramolecular motion. This is the meaning of the so-called law of equipartition.

Notwithstanding the great success of classical statistics, it is possible to overlook the fact that in certain fields there is great disagreement between the conclusions of statistics and actual experience, as is the case, for example, in the calculation of specific heats of gases at very low temperatures. In the quantum theory, particularly in Bohr's model of the atom with its discrete paths of electrons, statistical justification of all possibilities including the law of equipartition is entirely impossible. The difficulties of classical statistics are avoided in its modern developments. Thus, the new statistical theory of gases proposed by Bose-Einstein and Fermi agrees quite well with actual experience. The author emphasizes that the statistical method is not tied to a dogmatic system, but appears to be highly capable of extension and adjustment.

### Statistical Method Has Been Inadequately Applied in Technology

While many sciences are using the statistical method extensively, technology has been standing aloof as if in its field there were no room for the statistical methods. In so far as technology has made use of mathematical auxiliaries, which has been done on a large scale, it has always been the infinitesimal calculus that has been used, i.e., causal thinking.

In technology a high degree of safety is required and one cannot rely on luck, accident, and probability. On the other hand, however, there are extensive fields, such as management and factory organization, where mathematics is probably not used at all and pure empiricism reigns supreme. This lack of use of mathematics is not due to a neglect of these branches of technology but to the nature of things. So many factors come into operation in such branches as management and factory organization that the causes and effects cannot be clearly established and hence the functional relationship cannot be easily formulated. Plank cites many references to support this view, and points out that in practically all of these cases only very little attention has been devoted to the application of statistical methods to technology.

### Metatechnics Should Make Technology a Component Part of Culture

Among other things, Plank comes to the following conclusion: Just as side by side with physics there is a metaphysics which need not be feared provided it is directed into proper paths and deprived of its mystical accessories, so there should be no fear of placing side by side with technics a new science of "metatechnics," the purpose of which is to convert narrow technical specialists into generally well-educated creative engineers and men. Under the term "metatechnics" should be included all technical and economic thinking and creation lying beyond the limits of what can be calculated and expressed by formulas and drawings. By means of metatechnics, the mighty creations of technology are organically incorporated into the total structure of our spiritual being. By it civilization should become a component part of culture.

## Aircraft's Debt to Metallurgy

IT HAS been said that recent successes in the conquest of the air have been owing largely to improved metals and alloys, that the more powerful planes and engines are the result of new developments in metallurgy and heat treatment. This is, to a large extent, true in the case of alloy steels and alloys which go into the engines. There is an increasing use of nitrided alloy steels and of the strong light alloys of magnesium, both of which have been developed to a commercial status since 1927. A lighter engine of strength equal to or greater than that of earlier ones has been made possible. But chrome-molybdenum steel tubing still constitutes the backbone of the present plane, improved, however, by better processes of manufacture and more refined methods of heat treatment. Apart from the progress made in reducing the frictional resistance of the plane to movement through the air, as well as other effective refinements, metallurgy and heat treatment undoubtedly are responsible primarily for the success both of yesterday and today, admitted that there is enhanced skill in piloting and navigating. The exploits of 1931 in speed and endurance certainly are proofs of the dependability of modern aircraft and highly encouraging respecting its immediate future.—*The Iron Age*, Aug. 20, 1931, p. 521.

# Accident Prevention Through Safety Engineering

By DAVID S. ANDERSON,[1] BIRMINGHAM, ALA.

ACCIDENT prevention through "Social Engineering" does not seem to have had the attention it deserves. This is in reality the starting point for accident prevention, and if ignored, a poor beginning is made. "Social Engineering" contemplates the ascertainment of all available facts regarding an applicant for employment—his age, health, habits, bodily infirmities, reputation, family and family connections, antecedents, education, experience, etc. The employment is a contract entered into by him and his employer, and should be in writing. A written application for employment should embody replies to an exhaustive questionnaire. A physical examination by a competent doctor is essential, and pertinent and proper items as to the applicant's physical and mental ability to undertake the work applied for, or any other work to which he might likely be transferred or promoted, should be recorded in writing. Before approval of the employment the employing official should be satisfied in regard to these matters, as well as all other mentioned essentials and the references offered. An experienced safety engineer with such data can forestall many accidents and difficulties by selecting only those who are suitable physically and mentally. The doctor's report should point out all incapacitating diseases, hernias, defects in eyesight (which undoubtedly are the causes of many accidents), limb shortening, permanent injuries and scars, some of which might not especially disqualify the employee from the work applied for, but once disclosed and recorded become most valuable as information for future use in respect to claims for damages or workmen's compensation. With such applications and reports of medical examinations on file, and with further accumulation of experience in regard to accidents and other pertinent information properly indexed and filed, the employer has indeed a useful record of facts, which is very likely to become valuable in the future in many ways.

Generally speaking, the primary object of the construction of a plant or the making of a machine is to manufacture some useful, salable article for trade and commerce, without regard to dangers to the human agency necessary to operate it. After that, however, comes the duty to make the product as safe as possible. If the Wright brothers had been too strongly imbued with the idea of personal safety they would have remained on the ground, and no doubt the coming of the airplane would have been deferred; but once taking the risk and recognizing the hazard, it then became essential to make flying as safe as human ingenuity could make it. So it is with machines. Common sense warns men that machines in general are dangerous, but education, reason, and experience reveal to them ways in which they may be safely operated. Engineering which designs and creates safely operating machinery that increases production and decreases the number of men necessary to be employed, is a factor making for accident prevention on a large scale. It would seem a truism that the fewer men one employs the fewer accidents he will have. But, with no reduction in the number of men, the introduction of mechanical devices often results in an increase in accidents, due possibly to the slowness with which many mature men learn the principles of modern mechanics and the failure of many managers to properly supervise such work—and sometimes primarily because the designer has ignored essential safety principles. Engineering, instruction, and supervision must proceed hand in hand, and keep pace with each other, to secure real results in accident prevention in any industry.

## Classification of Accidents

Of late, accidents have been distinguished into lost-time and no-time-lost accidents. The Bureau of Mines defines the former as one that causes disability beyond the remainder of the day on which the accident occurred, while the rule with the Bureau of Labor Statistics of the U. S. Department of Labor is that a lost-time accident is one in which the disability arising from the accident continues longer than the day, turn, or shift on or in which the accident occurred. In view of the fact that it is possible to work great injustice to the injured man through such a dual classification of accidents and for much general harm to result to good morale and cooperation on the part of employees—which is a most essential element of success in accident prevention—it is hoped by some that a different formula or mode of distinction will in time be adopted, if any distinction between the two is indeed desirable. Sometimes the temptation is great for the safety engineer or foreman striving for a low accident-frequency record to require

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a slightly injured person to report for duty at the beginning of the next shift and perform work of some sort for an hour or a portion of a day at least in order to bring the case within the rule of classification of a no-lost-time accident. To say nothing of the injustice to the employer in placing a man on the payroll who is unable to earn his pay, the safety engineer or foreman so doing would be using his own unskilled judgment as to the extent and probable effect of the injury, thus invading the prerogative of the doctor (to whom all injured persons should promptly be sent), and would possibly endeavor to influence the doctor to minimize an injury, to the ultimate detriment or harm of the injured person. Putting an employee back to work under such circumstances is very often most harmful and sometimes results in infection of a serious nature, the bad effects of which the doctor would probably avert by prescribing rest for the injured employee for a short period, with proper treatment and dressings under sanitary surroundings conducive to rapid recovery. The doctor, for his own protection against damage suits for malpractice, should of course insist on his full prerogative in such cases and not permit any one to warp his medical judgment, or persuade him to do less than his full duty to his patient, whom the injured employee really becomes.

Assuming that accidents will still continue to happen in the iron and steel industry, would it not be wise for the safety engineer, regardless of the secondary question of lost time, to insist on full reports, not only of all accidents involving physical injury, but of all near-accidents as well, for intensive local study and analysis? An unreported accident or a suppressed report of one is a positive loss to accident-prevention research. The analysis mentioned should develop the cause and effect of many accidents. Some industries compile percentages of accidents by the various causes, the number of the different members of the body affected, the time of day, week, and year of occurrence, etc. Proper educational, supervisory, and engineering principles applied to such direct information and analysis would go far toward disclosing means for much accident prevention as this would indicate where and when accidents are most likely to occur, as well as the portions of the body usually most affected, wherefore a preventive could be more easily found.

### Accidents More Frequent During Periods of Industrial Depression

Accidents are most likely to occur during times of financial depression when workmen value their jobs most. In such times many of them become timid and nervous, have fears of being discharged, and are incapable of using their best judgment in doing work well and without hazard to themselves and others. This factor of fear is also instilled by other circumstances, and frequently by the overemployment of safety posters, safety programs, contests, and the like.

Much value is attached to rules of safety and conduct. Most men will not knowingly violate a rule of safety, and if the supervisory authorities will promptly apply strict and severe discipline to all that do, accidents can be much reduced. Disobedience has been a recognized sin since the day of Adam and Eve, and any man who violates a known rule of safety should be discharged. Accidents are man's worst enemy: they maim his body; bring pain and suffering; stop the pay envelope; create widows and orphans, and bring them to want. Are we not therefore warranted in saying that almost any means for accident prevention is justifiable.

The safety engineer's most serious job is not to invent new machines and methods, but to faithfully and fully inspect all existing machines and conditions for hazards. Discovered hazards should not merely be tagged as such and left for later repair. "Do it now" is the only correct motto for their removal. In some plants the safety engineer has authority to stop any machine or operation until a discovered hazard is remedied. Efficient safety engineering demands as additional means of accident prevention a clean, orderly plant, free from stumbling and slipping hazards, with plenty of light and air, and good housekeeping—which means orderliness and tidiness and is an inspiration to a workman; workmen in good health and of good habits who obtain the necessary hours of rest and sleep, and good, wholesome food; observance of rules of safety and conduct; ample supervision and instruction; friendly contact and cooperation with the workmen; the banishment as far as possible of the causes of fear of loss of position, or nervousness; and attractive, easily accessible, and well-defined points of entrance and exit, and safe routes for the workman to and from his work.

In conclusion, may we not be pardoned for saying that there is no mystic formula for accident prevention; that an absolutely safe and foolproof machine is undesignable; that what is to be is going to be, especially if a predicate is assumed; that, like the poor, we shall have accidents with us always, and all our discussions, all our papers, and all our efforts, to be effective, must center around the idea of the removal of the causes of accidents by stimulating the exercise of a progressive sense of care, which, as a nucleus given by nature, is already in fact being exercised—to a faulty degree, however—by every living being every conscious hour of the day; and to sum up in the briefest terms, let us all say, "Be careful, and keep on being careful."

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An interesting scientific adaptation of the burning mirror has been made by two Swedish scientists who have constructed a melting furnace for scientific purposes by using an elliptical mirror and an electric arc lamp as a source of heat, instead of the sun. During a recent demonstration the inventors obtained a temperature high enough to melt a metal with a melting point of about 2100 deg. cent. At another test the mirror was focused on a piece of platinum, which, in four minutes, was melted and brought to boil like a liquid.—*The Engineer*, May 15, 1931, p. 543.

# The Continuous Centrifugal

## Problems of Clarification, Hydro Extraction, and Separation Solved by the Continuous Centrifugal—Separation of Solid From Liquid—Centrifugal Treatment of Emulsions—Special Developments of Low-Speed Centrifugals

By E. M. JAMES,[1] PHILADELPHIA, PA.

CENTRIFUGAL machinery, mainly the hydro extractor or bottle centrifuge, has been used in industry for many years. Both of these machines are of the non-continuous-batch type, the former being a filter in which the pressure supplied by gravity head or pumps is replaced by centrifugal force.

Except for its use in the dairy industry, the high-speed centrifugal remained relatively unknown until recently. The super centrifuge was developed in response to a demand for equipment to handle many problems for the solution of which both gravity settling and filtration are unsatisfactory or impracticable.

The industrial problems which are solved by the continuous centrifugal fall roughly into three classes:

1 Separation of solid from liquids, in which the principle of filtration cannot be used, or clarification
2 Separation of solid from liquid, which depends upon the principle of filtration, or hydro extraction
3 Resolution of more or less intimate mixtures of two immiscible liquids, or separation.

Problems falling under (1) are attacked by both low- and high-speed machines; under (2), by low-speed machines alone; and under (3), only by high-speed machines.

Let us first consider the separation of solid from liquid, designated above as clarification.

### Separation of Solid From Liquid

For a clear understanding of the work performed by a centrifugal, it is desirable to review briefly the phenomenon of gravity settling. If a system consisting of a suspension of water and coarse solids, such as ferric oxide or silica, is allowed to stand, the components will separate into sharply divided layers whose relative positions in the containing vessel will be in the order of magnitude of their specific gravities.

Stokes' law, which may be expressed by the equation

$$V = \frac{2r^2a(S - S^1)}{9\eta}$$

where $V$ = velocity of settling
$r$ = radius of the suspended particle
$S$ = specific gravity of the suspended particle
$S'$ = specific gravity of the continuous phase
$a$ = accelerating force, and
$\eta$ = viscosity of the continuous phase,

formulates the influence of these various factors in determining the rate of separation.

When the accelerating force is gravity, $a$ becomes the gravity constant, and $V$ will have one value, but where $a$ is a high centrifugal force equal to many thousand times the force of gravity, the value of $V$ will be correspondingly increased. When a suspension is subjected to centrifugal force by passing it continuously through a rotor or bowl revolving about a vertical axis, centrifugal force acting outward from the center of rotation causes the denser of the two components in the system to move toward the periphery and to collect against the wall of the bowl. Thus if the specific gravity of the suspended solid be greater than that of the dispersing medium, the solid will be found in a compact mass adhering to the wall of the rotor or bowl. However, should the specific gravity of the suspended matter be less than that of the dispersing medium, it will be found at a point near the axis of rotation, and will collect in a column on the inner surface of the rotating liquid.

When the suspended matter of a two-phase system is so finely divided as to exhibit Brownian movement, the tendency of the disperse phase to distribute itself uniformly throughout the continuous phase is opposed by the force of gravity and an eventual equilibrium is reached.

If such a system which has reached equilibrium be subjected to high centrifugal force, the equilibrium will be altered, and in many cases practical separation as defined above be obtained. Thus the high-speed centrifuge is sometimes capable of separating suspensions which will not separate by gravity under any condition.

At this point let us digress to consider what the super centrifugal is, and how it is constructed.

The well-known equation for centrifugal force,

$$F = KN^2r$$

where $F$ = number of times the force of gravity developed
$r$ = radius
$K$ = 0.0000284 when $r$ is expressed in inches
$N$ = r.p.m.,

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Presented at a joint meeting of the Process Industries Committee of the A.S.M.E. and the American Institute of Chemical Engineers at Swampscott, Mass., June 12, 1931. Abridged.

shows that while the force developed varies directly as the radius, it also varies as the square of the r.p.m. Furthermore, the bursting strain to which a revolving centrifugal bowl is subjected is in direct proportion to its peripheral speed. It follows, therefore, that a rotor of small diameter can be driven at a high speed, and at the same time have a large factor of safety.

The commercial super centrifuge operates under normal conditions at a speed of 15,000 r.p.m., to deliver a separating force of 13,200 times gravity. For laboratory use a machine has been developed which operates regularly at 40,000 r.p.m., to deliver a force of 39,700 times gravity.

The power required at 1500 r.p.m. to overcome friction and windage is 1 hp., and the power required to accelerate liquid is 0.2 hp. per 1000 lb. of liquid throughput per hour. For example, a centrifugal clarifying an aqueous solution of specific gravity 1.0 at a rate of 250 gal. per hour would require approximately 1.4 hp.

The super centrifuge then consists essentially of a suspended tubular rotor or bowl supported by suitable bearings. The liquid to be treated is either pumped or fed by gravity at the desired rate into the bottom of the bowl. By means of a three-wing device it is brought instantly up to speed, and after passing upward in a hollow column it overflows into the covers and out of the cover spouts, whence it runs by gravity into any suitable receiving container. Where batches of material are being handled, this may be either a small floor tank or a drum. Solids are retained in the bowl. In large installations the effluent is usually received in funnels connected to a header leading either to a large storage tank located on a lower floor, or to a pump which conveys the liquid to another part of the building.

The capacity of the rotor for solids is approximately 231 cu. in. The duration of a continuous run therefore depends entirely upon the percentage by volume of the solids removed from a given liquid, and upon the capacity of clarification. Thus a run of one hour between bowl cleanings would be obtained when a suspension yielding 1 per cent of bowl cake is centrifuged at a rate of 100 gal. per hour. If the capacity be doubled, the duration of the continuous run is halved, and so on.

The commercial super centrifuge accomplishes its separations in times varying between $6^2/_3$ min. and $3^1/_2$ sec., with an average period of 25 sec. as the time which a unit volume remains in the bowl. The lower figure corresponds to a throughput of 10 gal. per hour—used in the recovery of bacillus acidophilus from broth—and the higher to a throughput of 1200 gal. per hour—used in the dehydration of transformer oils.

In practice, the results obtained with the super centrifuge depend upon three principal factors:

First, the effective mass of the particles of the disperse phase; effective mass being defined as the product of actual mass by the difference in specific gravity between the continuous and the disperse phase.

Second, the viscosity of the medium through which the particles of the disperse phase must move. Such viscosities may be so great as to cause the rate of subsidence under centrifugal force to be beyond practical limits.

Third, the time which a unit mass of the liquid being treated is subjected to centrifugal force.

In many cases, however, the effective mass of the particle may be increased or the viscosity of the continuous phase decreased by dilution or by raising the temperature. This procedure, while often of great assistance to gravity settling of the disperse phase, is frequently impracticable on account of convection currents which tend to oppose subsidence. Convection, however, plays no part in the rotor of a super centrifuge.

Often the cost of heat applied over long periods of time is found to be prohibitive. Further, when perishable products are being handled, gravity settling with or without heat is usually ruled out on account of deterioration during the time required for subsidence.

The influence of viscosity upon capacity for the same degree of purification is illustrated by Fig. 1,

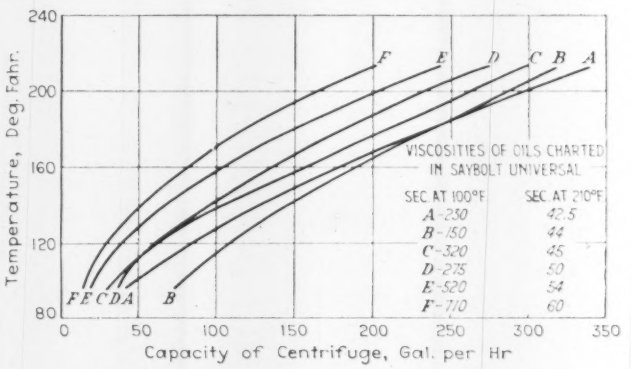


FIG. 1 CAPACITY-TEMPERATURE CHART FOR REPRESENTATIVE LUBRICATING OILS

in which the capacity of a centrifuge in gallons per hour is plotted against the temperature of centrifugation. Six oils covering a wide range of viscosity, and corresponding to standard commercial brands, were chosen, and in the tests undertaken were all badly carbonized and very dirty.

It is at once obvious that centrifugation at low temperatures and high viscosity would give so low a capacity in gallons per hour that centrifugal treatment would be uneconomical.

To set an absolute limit for practical operation, viscosity alone being considered, is extremely difficult. However, the most viscous material which the author has ever known to be successfully treated commercially was a nitrocellulose film dope dissolved in acetone. The impurities to be removed consisted of poorly nitrated cotton and some inert material, probably contained in the cotton as received for nitration. The contaminating substances resulted in specks in the finished film which were noticeable as dark spots on the screen when the film was projected. The dope, under a pressure of 40 lb. per sq. in., was fed to a super centrifuge at a capacity of 40 gal. per hour, and an effluent

free from the speck-forming impurities was obtained.

There is one class of dispersoid which is extremely difficult to sediment completely with a super centrifuge, although it will settle rapidly by gravity. A typical example is freshly precipitated ferric hydroxide, in which subsidence is accompanied by agglomeration. When such a suspension is passed through the super centrifuge, unless actual coalescence has occurred the suspended particles are partially deflocculated and only a portion will be deposited in the bowl. If the effluent from the centrifugal is allowed to stand, agglomeration will again take place, and a certain amount of solid will be precipitated.

However, though sedimentation under centrifugal force is not altogether complete in such cases, advantage can be taken of the fact that the solid removed is much freer from liquid than is the case where gravity settling alone is employed.

The sedimentation of bacillus acidophilus from broth culture furnishes an interesting example of the ability of the centrifuge to remove finely divided solids. The bacilli, which vary in length from 1 $m\mu$ to 3 $m\mu$ and have a diameter of approximately 0.5 $m\mu$, are formed in the broth culture under carefully controlled conditions. When the concentration of the bacilli has reached 1,500,000,000 per cc., the broth is ready for centrifugal treatment. It is fed through a battery of 16 super centrifuges at the extremely low rate of 10 gal. per hour per machine, and the effluent, whose bacterial count has been reduced to 25,000,000 per cc., is wasted. When the centrifugal rotors are opened, the bacilli are found adhering to the walls of the bowl in a putty-like mass. From this form they are worked up into a special preparation, providing extremely high bacterial concentration.

Filter presses and centrifuges are both used for removing solids from liquid, but they are seldom interchangeable. Each has its field of most effective operation, depending upon the difference in action and the individual material to be treated.

The efficiency of a filter press depends upon the deposition of the solids upon the face of the filter cloths in such form as will permit a continuous flow of liquid through the cake thus built up. If the solids are slimy, they will quickly clog the pores of the cloths, raise the pressure, and frequently break open the press. The super centrifuge is subject to none of these limitations, since the solids are collected against the wall of the bowl and a clear liquid flows away from and not through the mass of separated material. A good example of this type of problem is the removal of finely divided solids from heavy varnishes, which are difficult to filter, but which are readily clarified on passing through the super centrifuge.

The super centrifuge has found a very wide field of application in the removal of dirt and carbon from lubricating and fuel oils. Lubricants from all styles of stationary engines are continuously purified and returned to service, thus greatly reducing the make-up required, and prolonging the life of the wearing parts, which are always assured of an adequate supply of clean oil.

The centrifugal clarification of fuel oil has not only relieved the engineer from troubles caused by the clogging of burners, but has also made it possible to purchase a lower grade of oil than could formerly be used. In this case also a separator bowl is employed to eliminate any large amount of water contaminating the fuel.

When suspensions are treated in the super centrifuge, in which a certain portion of the dispersed solids is in an extremely finely divided state, centrifugal force will remove the coarser material, and leave the very finely divided solids suspended in the continuous phase.

### THE CENTRIFUGAL TREATMENT OF EMULSIONS

An emulsion may be described as a stable mixture of two immiscible liquids, which for convenience may be designated as oil ($A$) and water ($B$). Either $A$ or $B$ may be the continuous phase; hence there are two possible types of emulsions, oil-in-water and water-in-oil.

Pure oil and pure water will emulsify only with the greatest of difficulty, and when a stable emulsion is finally formed after prolonged agitation in a shaking machine or by refluxing the two liquids together, it contains only a very small proportion of the disperse phase. However, should a third substance be present which will act as a stabilizer, it is possible to suspend large quantities of water-in-oil (certain naturally occurring stable emulsions of salt water suspended in crude petroleum contain as high as 70 per cent of the disperse phase) or of oil-in-water. These stabilizing substances are known as emulsifying agents, and their ability to dissolve in or to be wetted by one of the liquids, determines which shall be the continuous and which the disperse phase.

Other emulsifying or stabilizing agents are glue, gelatin, gum arabic, albumen, etc., which promote the suspension of oil-in-water. Finely divided carbon, clay, asphaltum, and naphthenic acids stabilize emulsions of the opposite type.

Bearing in mind the foregoing, it is at once obvious that the resolution of emulsions under centrifugal force consists of two distinct steps: (1) the subsidence of the suspended particles of the disperse phase and (2) coalescence of those particles after subsidence.

The super centrifuge has proved exceedingly valuable in the rapid dehydration of oils which occur industrially in emulsions with water—for example, fish oil—and which, if the force of gravity is depended upon, either deteriorate through contact with the aqueous phase at the temperature and settling periods which are necessary for subsidence under gravity to take place, or are partially lost through evaporation under similar conditions.

Another instance is the dehydration of crude petroleum. The oil as pumped from the well contains a considerable quantity of emulsified salt water, the stabilizing agent being finely divided clay. The emul-

sion may be concentrated by gravity settling in tanks equipped with heating coils, but such procedure entails the loss of some of the light ends from the oil and requires a large amount of steam. The super centrifuge is not only able to produce a satisfactory pipe-line oil, but at the same time resolves the greater part of the emulsion which settles out under the influence of gravity, by causing subsidence of the stabilizing agent. The operation is much more rapid than the old method, and evaporation losses are reduced to a minimum.

The super centrifuge has been extensively used in the purification of transformer oil. The oil in the transformer becomes wet through the condensation of the moisture in the atmosphere when the transformer breathes, and the presence of such water causes the dielectric of the oil to be very considerably lowered.

Oil which has been used in switches and circuit breakers becomes contaminated with carbon and organic acids produced by the oxidation of the oils in the presence of the arc momentarily caused by operating the switch. These organic acids not only raise the acidity of the oil to an undesirable point, but also lower its resistance to emulsification. In turn, the presence of water and finely divided carbon in the oil lowers its dielectric and greatly impairs its usefulness. In order to restore the dielectric of this contaminated switch oil, a special process embodying the use of the centrifugal has been devised.

An interesting application of the super centrifuge, which involves the continuous discharge of wax-like solids, is found in the dewaxing of lubricating stocks. This process forms the type of that condition above mentioned where, in a three-phase system consisting of two immiscible liquids and a solid, the latter is of lower specific gravity than the heavier of the two liquids.

Steam cylinder stocks which are used to give body to motor oils will solidify at a relatively high temperature when filtered to a color acceptable to the trade. Solidification is due to the presence of amorphous wax or petrolatum, and in order to produce a lubricant which will remain liquid at low temperatures, this wax must be removed.

If a chilled suspension of wax in cylinder-stock naphtha solution is centrifuged, the wax will collect in the rotor of the centrifugal and clear oil will discharge, but unless extreme care is taken, it is almost impossible to discharge the wax satisfactorily. However, through a special design of the centrifugal rotor and the use of a carrier liquid heavier than the wax and immiscible with the oil-naphtha solution, it was found possible to discharge the wax continuously and to produce a bright stock which, after reduction, showed a cold test in the neighborhood of 15 deg. fahr. The chilling period, and in consequence the refrigeration cost, was greatly reduced, and the yield of bright stock was increased to 85 per cent.

Further design and experimentation brought to light the fact that long residuum (i.e., still residue which contains all of the lubricating stocks in a given crude) could be handled by the centrifugal dewaxing process and thus be made to yield a dewaxed low-cold-test oil.

Centrifugal dewaxing has been extended further to cover the treatment of various heavy distillates, in which by careful control the wax had been carried out in the amorphous form.

More than 10,000 barrels of oil are now being dewaxed centrifugally daily in the refineries of the United States.

### Developments in Low-Speed Centrifugals

The greatest use for the low-speed or basket type of centrifugal has been in the process of hydro extraction. In the textile industries this hydro extraction has taken the form of wringing water and solutions from hanks of yarn or finished pieces of material.

In the chemical industry the materials handled are usually crystalline solids which will form a free-draining cake, thus allowing the liquid or mother liquor to drain through the perforations in the basket wall and into the casing or frame of the centrifugal, whence it is led away through a pipe.

One industry in which the vertical hydro extractor was frequently used was in the production of ammonium sulphate by by-product coke ovens. The slurry of the salt and mother liquor was led from the saturators into the basket of the vertical suspended centrifugal, and the mother liquor extracted by centrifugal force. With the machine still operating at full speed the mass of crystals was washed with a small amount of hot water, this wash water expressed, and the machine then unloaded by stopping the bowl and scraping the crystals from the basket wall with large wooden paddles.

The labor involved in this operation was extremely arduous, two men being often required to handle four centrifugals; further, it must be remembered that production usually lasted 20 hours out of the 24.

To meet this condition and similar ones a modified type of basket centrifugal has been produced. The novel feature consists in the use of a horizontal basket supported at both ends instead of being suspended, and an unloading mechanism which will unload the basket while the latter is running at full speed. Great economies in power are thus effected and in addition a greatly increased output with very much lower labor cost is possible per centrifugal.

In addition to the increased production per machine and the economies in power possible, the horizontal centrifugal has also considerably improved the quality of the product, through much more efficient rinsing.

The horizontal extractor is provided with a basket 63 in. in diameter and runs at a speed of approximately 500 r.p.m. It is usually driven by a direct-connected motor.

In one plant making large quantities of ammonium sulphate, six 40-in. vertical extractors were used continuously, while two more were held as stand-bys. The salt production was approximately 50 tons per 24 hours.

Installation of two horizontal centrifugals equipped with hydraulic unloaders, one acting as a stand-by,

has displaced the eight verticals, and reduced the labor on the centrifuge to one operator, where five were formerly required. The ammonium sulphate produced contains 2 per cent of moisture and 0.15 per cent acid, and is conveyed directly to the storage bins from which it is loaded into cars for shipment.

By the use of a fully automatic unloader, i.e., electrical control providing for the loading, wringing, rinsing, and unloading, it has been possible to increase the production of one machine to over 90 tons per day.

There are many liquids occurring industrially which it is necessary to free from solids, but in which the solid matter is of such a nature that it will rapidly clog the pores of filter cloth, and therefore cannot be handled in filter presses. At the same time, the proportion of solids is so great that clarification by means of a super centrifuge is out of the question on account of the frequency with which bowl cleaning becomes necessary.

In certain cases it has been found possible to clarify such liquids by treating them in a large, low-speed centrifugal equipped with a solid basket instead of a perforated one. Sometimes it has been found advantageous to use the large, slow-speed machine as a preclarifier ahead of a battery of super centrifuges.

The horizontal centrifuge has been adapted in certain cases to such problems. Unloading while at full speed is carried out as with the extractor type, but the liquid, instead of discharging into the casing of the centrifugal, is hooked off by means of a curved discharge nozzle attached to a pipe. The force with which the liquid leaves the bowl through the curved nozzle is sufficient, at capacities in the neighborhood of 1000 gal. per hour, to raise it 10 ft., and this property is very frequently of advantage.

A typical installation for which one of these solid-basket machines is used in series with a battery of super centrifuges is the continuous purification of wool-scouring liquor.

A wool-scouring train consists of four or five shallow tanks known as "scouring bowls." The first and second bowls usually contain a solution of soap and soda ash, while the last two or three bowls are for purposes of rinsing. The wool to be scoured is fed continuously into the first bowl containing the hot solution above mentioned, and is thoroughly doused in the liquor as it is moved forward by means of a set of oscillating rakes. At the far end of the bowl the wool enters squeeze rolls which free it is far as possible from the liquor and it then passes down the train in similar fashion through the remaining bowls.

The impurities which the soap-and-soda solution remove from the raw wool consist of dirt, potash salts arising from dried perspiration, and wool grease. The bulk of these impurities are collected in the first bowl, and in ordinary operation it is necessary to discard the liquor at the end of 12 hours' operation. This entails the dumping of upward of 5000 gal. per 24 hours of dirty scouring liquor into the nearest stream, which causes serious pollution owing to the rapid fermentation of the solids in the liquor, both soluble and insoluble. When the first bowl is dumped the contents of each of the other bowls is moved forward and fresh solution is added to the last bowl.

In the centrifugal installation a horizontal centrifuge having a solid basket 48 in. in diameter (which is the size in which these large decanters are made) draws liquor continuously from the scouring bowl at a rate of approximately 800 gal. per hour. The effluent is split into two parts, one being returned to the scouring bowl. The greater part of the dirt contained in the scouring liquor adheres to the wall of the basket in the form of a putty-like cake, which is removed by the knife at stated intervals, usually once every hour.

That part of the liquor not returned to the scouring bowl is heated to a temperature of approximately 160 deg. fahr., and fed continuously to a battery of two super centrifuges, operating at a capacity of 200 gal. per hour each. The residual dirt is collected in the bowls of these centrifuges, while the liquid discharged as a heavy effluent is fed back into the scouring bowl, having been purified from everything except soluble salts and a small amount of wool grease. The light effluent consists of an emulsion of wool grease and soap water.

The light effluent is collected, heated to 180 deg. fahr. with water in a small auxiliary tank, and the mixture is passed through a third super centrifuge. The heavy effluent from this machine consists of dilute soap water which is run to the sewer, while the light effluent is dry wool grease, containing only traces of moisture, which grease is barreled and sold.

The centrifugal process greatly simplifies the problem of stream pollution in view of the fact that only a small amount of the liquor is wasted to the sewer each day, it greatly decreases the amount of soap and soda ash required for scouring, since it takes advantage of the scouring properties of the naturally occurring potash salts, and in addition it produces a salable grease of a fatty acid usually under 3 per cent.

In certain cases even the dirt from the horizontal and the super centrifuge is saved and sold as fertilizer.

In addition to the two sizes of horizontal centrifugals already described, a third machine, 20 in. in diameter, has been developed. This machine operates at a speed of 1800 r.p.m., thus generating a very considerably greater centrifugal force than either of the larger machines. It is built both as a decanter and as a hydro extractor, and the unloading mechanism is operated by hand.

The capacity of this small machine operating as a decanter varies between 100 and 250 gal. per hour, and on account of its small size and high centrifugal force it can very often be profitably used where the volume of liquid to be handled is not sufficiently great to justify the installation of one of the larger machines. When in the decanter form, it can also be used as a preclarifier ahead of the super centrifuge.

Specific applications of the high-speed super centrifuge are numbered in hundreds, some of them consisting in centrifugal treatment alone, while others have

required considerable development of a process nature. The study of possible applications of low-speed machines of the decanter type is but beginning. The field continues to broaden for both types of machines, and without question in the future many new problems will be satisfactorily solved by the intelligent application of both high- and low-speed centrifugals.

## Discussion

A. E. FLOWERS[2] AND G. J. STREZYNSKI.[3] This paper covers quite thoroughly certain limited phases of centrifugal separation. However, the centrifugal, being a common part of all the processes discussed, and usually the least understood, deserves a few additional words.

Centrifugal force is discussed at some length, but the two other factors of equal importance in centrifugal separation are not mentioned. These factors are the time of action for the centrifugal force and the settling depth.

High-speed centrifugals may be divided into two classes: single suspension and double suspension. In the first class we find bowls which are larger in the diameter than in height, and therefore are gyroscopically stable so that a single suspension of the bowl is quite ample. In the second class we find bowls considerably longer than the diameter; these have no gyroscopic stability, and if suspended from one point while rotating would tend to turn at right angles to the axis of the cylinder. The separating effect for either type of bowl follows the law

$$S = \frac{F \times t}{d}$$

wherein $F$ is the separating force, $t$ is the time the force is applied, and $d$ is the distance through which the particle being separated has to travel. The same formula governs gravity settling, with appropriate values for the different factors. A single factor taken separately cannot express the effectiveness of separation.

For any given form, with the magnitude of the various dimensions varied, but in a constant ratio to each other, it may be shown that the relation between the separating effect and the diameter of a bowl is

$$S \propto R^{1.5}$$

This relation indicates that in the case of hollow bowls operating at the maximum speed allowable by the physical strength, the smaller-diameter bowl must be correspondingly longer for the same amount of separating effect.

As the height or length of the bowl increases in relation to its diameter, another significant change takes place. This change is clearly indicated in Figs. 2 and 3. Fig. 2 shows the theoretical flow lines utilizing all of separating effect due to the full diameter. Fig. 3 shows what actually happens. Localization of flow lines is unavoidable. There are sections where the flow is most violent and others where the liquid is practically stagnant and eddying. Part of the liquid follows the shortest path, which is through the center of the bowl where the separating effect is at its minimum, so that some portion of the processed liquid is always subjected to only a fraction of the full separating effect.

Bowls with high effective separating coefficients may be designed with quite different shapes, when all three separating factors are taken into account, but always by making up on one factor whatever may have been conceded on either of the others.

There is also a general lack of understanding of throughput capacity, and many cases occur in which purchasing agents and others ask for, or accept, figures which are merely the maximum *pumping* capacity, and so are not related to the real purifying capacity.

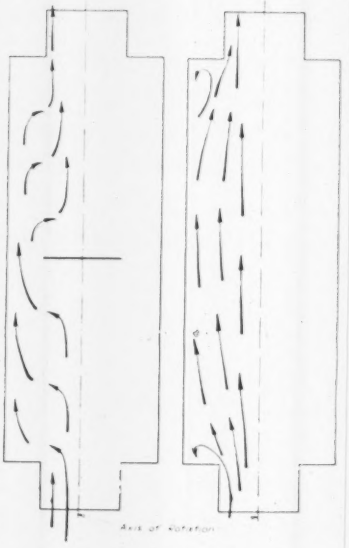

FIG. 2 FIG. 3

Examples of this are offered in the claimed ratings of lines of machines with bowl diameters of 3 in., 6 in., and 9 in., whose pumping capacities, in accordance with the 1.5 exponent of bowl radius would be

| | | | |
|---|---|---|---|
| as | 5.1 | 14.7 | 27.1 |
| and are given ratings of | 30 | 220 | 500 |
| instead of | 30 | 86 | 160 |

From this it is obvious that either the larger-size bowl is vastly overrated or the small one too good to be true.

The chart for separating capacities as a function of temperature for oils of different viscosities still leaves out of account the very large and important factors of the amount and kind of contaminant in the incoming oil and the *degree of purification* to be applied.

These may readily alter the real purifying capacity in ratios that are not infrequently several hundred per cent and may even be 1000 to 1.

Reputable manufacturers make a sincere effort to

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supply separators that will give real and adequate service to their customers, and quite generally make preliminary tests or conduct demonstrations to show just what size of machine is needed and just what performance may reasonably be expected. They have suffered and still suffer from unthinking competition and indefinite requirements. At present the best available means for selection lies in an actual trial.

There is a very great need for standards of purifying performance suitable for each class of service and relatively simple and accurate methods and apparatus for measuring the traces of impurities left after proper centrifugal processing. Considerable work has been done on these two questions and it may be expected that full information will be available for publication in the near future.

Cooperative work may then follow for the purpose of setting up standards for performance on acceptance tests.

## AUTHOR'S CLOSURE

Messrs. Flowers and Strezynski, have raised certain points which require elaboration.

In the first place, the statement is made that high-speed centrifugals are divided into two classes:

In the first class are centrifugals with so-called single suspension, with bowls larger in diameter than in height. In the second class are bowls with so-called double suspension, considerably longer than the diameter.

This distinction of single suspension and double suspension is quite misleading and ignores the actual facts of the designs. In the first class of centrifugals the bowl is mounted on the projected, overhanging, or cantilevered end of the spindle, and there are two bearings on this spindle, both on the same side of the bowl, the position of these two bearings determining the direction of the spindle and the location of the axis of the bowl. This mounting is satisfactory not because of the gyroscopic stability of the bowl, but because the bearing on the spindle closest to the bowl is flexibly supported so that errors in balance of the bowl do not result in unusual stresses in the cantilevered spindle and because a certain flexibility between the bowl and its spindle allows the bowl to rotate on its own natural axis.

In the second class of centrifugals, the bowl is suspended from a flexible spindle, the upper end of which is driven through the mechanical equivalent of a universal joint. The flexibility of this spindle is the equivalent of the flexible bearing and the flexible connection between the bowl and the spindle in the first class of centrifugals and the deflection of this flexible spindle permits the bowl to rotate about its natural axis. A long tubular bowl so mounted is gyroscopically stable, there is no tendency for it to turn at right angles to the axis of the cylinder, and it will operate as a rotating body without any other bearings, guides, or suspension. The guide at the lower end of the bowl in centrifugals of the second class is for the purpose of locating the rotating system, including the bowl, so that this rotating system has a definite position with respect to the frame, the stream of liquid flowing to the bowl, and the covers for collecting the liquid discharged from the bowl.

The statement that bowls having a length considerably greater than the diameter have no gyroscopic stability is contrary to the well-known laws of rotating bodies. A body will rotate with equal stability on an axis about which the moment of inertia is a minimum, as on an axis about which the moment of inertia is a maximum. A familiar example of the natural gyroscopic stability of a long cylindrical body rotating about its longer axis—that is, an axis about which the moment of inertia is a minimum—is a rifle bullet. The common rifle bullet has a length many times its diameter. A 3-in. bullet leaves the muzzle with a rotational velocity of approximately 30,000 r.p.m. about its longer axis. After it leaves the muzzle it is unconstrained and under these conditions continues to rotate about its longer axis, showing the natural stability of a body rotating about a longer axis. The rotation is given to the bullet largely for the purpose of maintaining its point foremost in flight.

Any one can try the simple experiment of tossing a pencil in such a way as to cause it to roll along the fingers, thereby giving it a rotational motion about its long axis. The pencil will continue to rotate about the long axis and will exhibit no tendency to rotate end over end as a result of energy derived from this primary rotation.

The long bowl of small diameter may be made with equal liquid content and hence equal time factor as compared with the short bowl of large diameter. Short particle travel is obtained by virtue of the thin liquid layer without resort to a series of stratifying baffles. As pointed out in the body of the paper under discussion, the bursting stresses in a centrifugal bowl are directly proportional to the peripheral speed and since it is common practice to build centrifugals of similar materials with about equal factors of safety, all centrifugals operate at approximately equal peripheral speeds. Of course, the smaller the diameter of the bowl the higher the rotational speed at which it is driven. Therefore, since the centrifugal force varies directly as the *square* of the revolutions per minute, the long bowl of small diameter may be designed with considerably greater separating effect, according to Mr. Flowers' equation

$$S = \frac{F \times t}{d}$$

than the short bowl of large diameter.

The illustration showing flow lines up the center of the bowl may represent flow conditions in the case of liquid passing through an absolutely plain tubular bowl. But tubular bowls are built with simple radial wings, which insure rotation of the bowl and all of the liquid contained therein at the same rotational speed, and make all paths substantially equal, thus eliminating unequal flow.

# Survey of Engineering Progress

## A Review of Attainment in Mechanical Engineering and Related Fields

## Noise

THE STUDY of noise with particular reference to aeronautics may be divided into two parts. Ultimately, of course, it is desired to determine the sources and magnitudes of the noises together with methods for, or as a preliminary tool to, their elimination. Just now, however, the development of reliable and convenient methods of measuring noises must be considered. The present paper deals with both of these features.

The author considers and describes several instruments for measuring noise. One is a portable microphone and amplifier unit which he himself has designed for general acoustical work and which will measure the overall acoustic pressures. Dials are provided for altering the sensitivity of the instrument in decibel steps over a range of 110 decibels. The instrument is also capable of measuring the intensity of components. The apparatus records the noise in the form of an oscillograph which may be analyzed for various features. This apparatus, while convenient for physical measurements, is not entirely suitable for use on airplanes where the aural methods are apparently favorable. The author then describes the Barkhausen apparatus and its modifications, and also describes the use of a tuning fork as a portable audiometer. It is surprising that the simple tuning-fork method has been found to give measurements of noise very closely comparable with those obtained by more elaborate apparatus.

### Decibel as Unit of Noise Measurement

The author uses the decibel as the unit of noise measurement. As R. S. Capon of the Royal Aircraft Establishment at Farnborough remarked in the discussion, the decibel was at first a difficult unit to deal with. It was very subversive of one's preconceived ideas, and the experimenters at the Royal Aircraft Establishment were very grateful to Doctor Davis for having given them some guidance in the use of a unit to which they were not accustomed. Doctor Davis had illustrated a difficulty one was likely to meet in using the decibel notation. One was apt to forget what a lot of noise could come through a very small hole. One might have a curtain which would eliminate 30 db. [decibels], but if there were a small hole in it of one-thousandth the area of the curtain, it would admit as much noise as was eliminated by the rest of the curtain.

On the other hand, the decibel notation conferred one great benefit. It showed that there was only one important sound at one time and that it was the noisiest of the group of sounds.

D. R. Pye, Deputy Director of Scientific Research, Air Ministry, noted that the decibel scale seemed to break down when applied to very low intensities of sound. For example, if there were two aircraft in the distance, each producing a noise, audible to the listener, of 1 db., the two machines together would produce a noise of 4 db., according to the formula. Putting the same difficulty in another way, if each of the aircraft was just inaudible to the listener, the two together would produce a noise of 3 db. Perhaps that was not a legitimate point to make in regard to aircraft noises, however, because aircraft noises were gross things—they were engineering problems, and not delicate physical problems.

As regards sound proper, Doctor Davis points out that one has to deal here with tone, pitch, quality, and loudness. When the aerial waves consist of a regular succession of vibrations the sensation is that of a tone, but an irregular non-repeating disturbance results in what is technically known as noise. However, in a wider general usage noise appears to refer merely to excessive unwanted sound.

Pitch is determined by the frequency of vibration, and the quality of sound by its wave form. Acoustical power and energy ratios are proportional to the square of amplitude ratios. Between the upper and lower limits of normal hearing the human ear can distinguish some 270 gradations of loudness at the frequency of 512 cycles per sec. but fewer at other frequencies.

### Comparison of Loudness of Noises

A comparison of loudness of pure tones of different frequencies is made by the author. There is as yet no accepted relation between loudness of a complex note and loudness of its various compounds.

It appears to be true that the sheer loudness of noises in many aircraft is extreme, and question of whether one type of noise or another is more distressing is rather a refinement. It is well perhaps to note that many persons unhesitatingly state that high notes are to them more annoying than low notes. Others claim that prolonged exposure to low notes is especially troublesome.

Laid and Coye (Acoustical Soc. of Am., *Journal*, vol. 1, no. 1, p. 158) conducted experiments on the loudness of notes of different pitches which were judged to be equally annoying to a number of observers trained in accustical work. They stated that annoyance reaction was similar to that experimented by rubbing one's finger over coarse sandpaper, and in hearing peanuts shelled during an overture. For notes below, say, 500 cycles per sec., the annoyance and loudness curves are parallel, i.e., the annoyance was determined by the loudness alone. But above this frequency there was a tendency for high notes to be specially annoying, particularly when they were very loud. It was not possible to discover a method of measureing annoyance, nor to determine a level of zero annoyance.

A brief discussion is given of the masking effect of one sound on another, particularly the masking of speech, after which the author proceeds to the subject of physical measurements of noise, noise analyses, and measurements of sources of aircraft noise.

The analysis of airscrew noise is particularly interesting. The conclusion to which the author comes is that one of the most obvious steps in minimizing airscrew noise is to use large airscrews and avoid high tip speed. This implies the use of reduction gear in the engine, and he shows from tests which he made that the reduction of airscrew noise by gearing was of the order of 10 to 16 db. With reduction gear, screaming of gears may

occur and might be serious, but there are indications that the reduction of airscrew speed by gearing can be made worth while.

It is worthy of notice that the noise level in this type of airplane—with a nose engine and two engines at the side of the passenger cabin—was about 10 db. higher in the plane of rotation of the side airscrews than in the rear. Clearly, if airscrews cannot be kept away from the sides of the cabin, luggage accommodations should be situated in the plane of rotation rather than passengers.

Of course it is not really possible to draw quantitative conclusions as to the cause of the improvements in cases where totally different machines are concerned, but it may be helpful to see how various measurements fit in. The author, for instance, notes that in another three-engined type of airplane—a high winged monoplane—with airscrews operating at the same tip speed as those in the geared machine previously mentioned, but with the side engines well in front of the passenger accommodation, noise levels of about 80 db. were observed as against 85 db. in the rear of the machine already referred to. The difference of 5 db. may have been due to the substitution of heavier cabin walls for the simple fabric, or to keeping the cabin wholly clear of the plane of the airscrews, or to a quieter engine.

### Noise Reduction in Airplanes a Highly Complicated Matter

Noise reduction is a highly complicated matter. If the source is a machine it must be balanced accurately so that it does not communicate vibration to the structure to which it is attached. The next step is to provide the machine with an enclosure to prevent the escape into the air of the noises emitted. Also, if possible, the source of vibrations should be insulated from the structure by substantial layers of materials, such as cork, felt, or rubber. It is well to remember, however, that the sound path and the vibration path are not necessarily independent.

The author next considers the subject of isolation of cabins in connection with which he reports sound transmission through single and double partitions of fiber board with or without a filler of cotton waste in between. For single partitions weight is the primary factor, and there is evidence that the panels transmit sound by virtue of the fact that they are set in vibration like diaphragms.

### Noise Levels in Commercial Machines

At present noise levels in commercial machines, stated in terms of the energy level of an equally loud note of standard pitch, range from 75 to 80 db. above threshold in the quietest tested to 110 db. in a cabin in the plane of the airscrews of a noisy one. In the latter noise, conversation is impossible. One can converse in a noise level of 85 to 90 db. above threshold on the scale, and when the level falls to 75 to 80 db. conversation may be carried on without great difficulty. As a result of a study of the sources of noise—airscrew, engine exhaust, and engine clatter—it appears that airscrews, when too high-speed, are the dominant cause of noise. Conditions favorable for reduction of airscrew noise are reduced speed, larger diameter, thin section, etc. The clatter and noise of an engine appear to be of the same order of magnitude, say, 100 db., above threshold, as an airscrew of moderate aspeed. Experiments suggest that airscrew noise can be reduced to, say, 80 db., and accordingly engine and exhaust noise demand attention. Probably something can be done by interposing wings as a screen between, say, the exhaust and the cabin, or by enclosing the engine. Some degree of exhaust silencing, say, 10 db., can be achieved by a simple perforated pipe. Further silencing may involve increased back pressure. The silencing of engines appears desirable, either by enclosing them, or, if possible, by redesigning camshafts, etc. to modify the motion of moving parts.

Laboratory experiments upon the exclusion of noise by the provision of insulating walls appear to indicate that a reduction on an average of the order of 30 db. may be attained, provided filled double walls of some $^3/_4$ lb. to 1 lb. weight per square foot are employed. Some reserve is possibly necessary in applying this result to an actual airplane. Assuming it applies, however, such a cabin would reduce the noise (100 db.) of the power plant outside the cabin to 70 db. inside. A further reduction could perhaps be attained in a design which located the power plant well forward or screened it from the cabin. Consequently the reduction of cabin noise to practically that (60 db.) in a railway train is within the bounds of early developments.

Presentation of the paper was followed by an extensive discussion which can be abstracted only briefly.

Doctor Tucker, of the Air Defense Experimental Establishment, Biggin Hill, England, said that the Siemens Barkhausen noise measurer had its limitations, and it was difficult to explain why it gave reasonably satisfactory results. There were several psychological problems connected with it, as, for example, the balancing of one type of sound with another of entirely different character, but for the time being these difficulties were able to be set on one side, in view of the exceedingly coarse measurements which had to be made. When one realized that the complete elimination of one engine from a double-engined machine resulted in a reduction of sound to the extent of only 3 db.—in a noise expressed by 100 db.— the coarseness could be appreciated. His experience in the making of measurements at Biggin Hill by means of the Siemens Barkhausen instrument had shown that good listeners could differ among themselves to the extent of 3 db., and, in regard to certain types of noise, by as much as 5 db., corresponding to an intensity ratio as between the two sounds of 2 to 1 or 3 to 1. It was remarkable that when the instrument was used for measuring noises which were sustained and steady, the consistency in readings was such as to justify Doctor Davis in quoting the figures given in his tables. When, however, one tried to use the Barkhausen instrument for low intensities and for intermittent sounds, such as were experienced in an engine room, for example, one was rather bothered, and the decibel scale seemed to go to pieces. It had always been rather a mystery to him as to why one could measure the intermittent noise of street traffic, pneumatic drills, etc., with any degree of certainty, and it seemed to him that some of the figures given were extremely speculative.

### The Problem of Airscrew Noise

A very interesting discussion was presented by H. Glauert, who is developing a theory concerning the noise of airscrews (not published in complete form). On first thought one would expect the noise to be mainly of the fundamental airscrew frequency, i.e., the number of blades times the rate of rotation, but in fact the observations showed that that frequency was not normally detected. Many years ago experiments had been made at Farnborough on the whirling arm, and when measurements were made it was found that the frequencies were generally far higher than the fundamental frequency. These results had led him to think that the frequency was other than the frequency associated with the fundamental, and he noticed that the frequency did in fact correspond very closely with the frequency one would expect from a cylindrical rod, or something similar, moving through the air at the same speed. The fact that the blade of an airscrew was moving in a circle altered the method in which one heard the noise, but the source of the noise was simply the rapid movement of the blades. The conception that the noise was due to the drag of the blades led to a

slightly different interpretation of the experiments which had been made, and therefore he had come to conclusions slightly different from those mentioned by Doctor Davis. For example, the experiments on the spinning tower were adjusted so that the blades absorbed the same power as they would on an airplane, the adjustment being made by changing the blade pitch, but the adjustment should have been made so that the blades worked at the same angle of incidence in their path through the air. The power was purely a subsidiary quantity. It was sometimes said that the noise made by an airscrew represented wastage of power, and that was true academically, but, on looking into that matter closely, he had found that the actual noise energy represented something of the order of one-thousandth of the power absorbed by the blades, so that if that energy were saved there would be no noticeable improvement of performance. In his opinion there was also another possible source of sound, apart from the drag of the blades, and that was the pressure system which accompanied each blade in its rotation. That system was intimately associated with the thrust of the airscrew, and his calculations suggested that it would give a noise of the same order of intensity at a position close to the airscrew. But, as it seemed to depend on the thrust power rather than on the thrust itself, that noise would not be appreciable in the experiments on the spinning tower. The drag noise, which was the dominant one in most cases, depended mainly on the tip speed of the airscrew, and varied as a very high power of that tip speed. That implied that the noise came almost entirely from the tips of the blades, and that the inner parts of the blades were not important. Improvement could be obtained by using thinner sections or sections of better airfoil shape, also by reducing tip speed by the use of gearing, and—this was a matter on which he differed with Doctor Davis—an improvement could also be achieved by using four blades instead of two. It seemed to him that by adopting those three changes in a reasonable manner one could obtain a reduction of the order of 40 db. We might then find the noise to be below the level of the thrust noise, but, fortunately, the thrust noise was also reduced if four blades were used instead of two. Therefore, the indications were that, from the point of view of noise reduction, we should use four-bladed instead of two-bladed airscrews as far as possible.

C. G. Grey, editor of *The Aeroplane*, said that most of the noise experienced in the cabin of an airplane was not airscrew noise as such, but was due to the battering of the wings, struts, etc., by the slipstream. If the engines could be placed out of the way of the structure of the airplane, so that the propeller would have nothing but air to work on, the noise inside the cabin would be much reduced.

M. L. Bramson, from experience in the flying of a plane arranged for sky-writing purposes, expressed the opinion that it would be beneficial from the point of view of reducing noise to have the exhaust orifice far back of the machine. (Dr. A. H. Davis, Physics Dept., National Physical Laboratory, England, in a paper before the Royal Aeronautical Society, April 16, 1931, published in the *Journal of the Royal Aeronautical Society*, vol. 35, no. 248, August, 1931, pp. 676–699, 9 figs., 8 tables, and discussion pp. 699–710, *et A*)

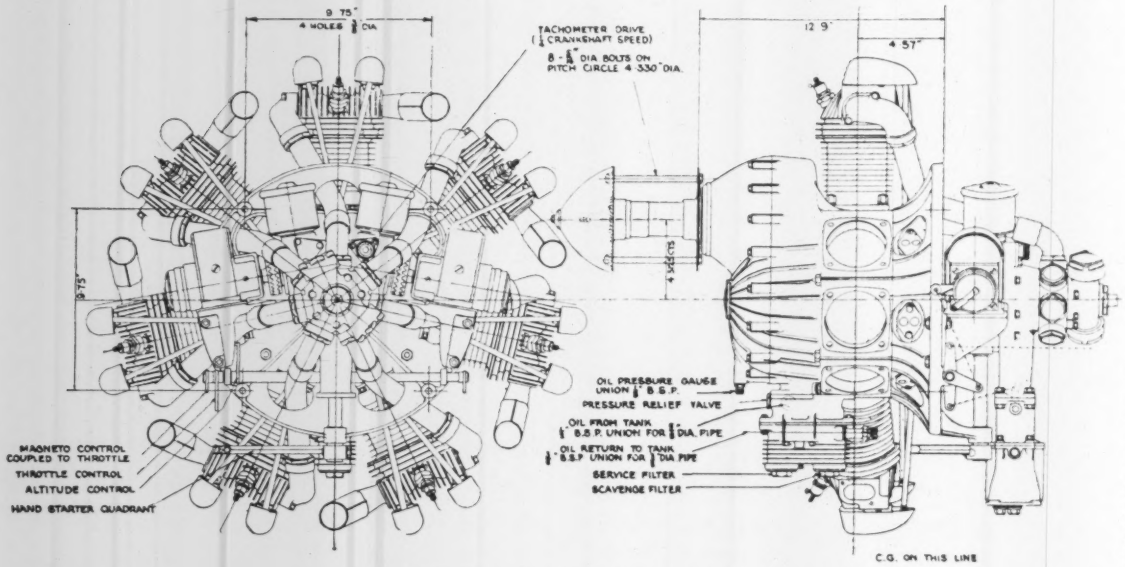


FIG. 1 THE POBJOY R-TYPE ENGINE

# Short Abstracts of the Month

## AERONAUTICS

### The Pobjoy R-Type Engine

THIS engine has recently passed the type tests imposed by the British Air Ministry and is now available for use in aircraft with full certificate of airworthiness. The remarkable features of this engine are the very low specific weight (1.73 lb. per hp. on normal power) and the fitting of a reduction gear which allows good propeller efficiency and gives good thrust horsepower for take-off and climbing. The normal engine rating is 75 b.hp. at 3000 r.p.m., and the maximum permissible speed for short periods is 3300 r.p.m., at which speed the engine develops 85 hp. The fuel consumption on Aircraft Ministry tests was found to be 0.53 pint per b.hp. per hr. The type tests were carried out with the special Pobjoy exhaust collector in place. This exhaust collector not only materially reduces the noise but prevents oil from being thrown back on the machine. The engine is suitable for light two-seater airplanes, the more so as the propeller reduction gear results in good airscrew efficiency. The engine is of the seven-cylinder radial air-cooled type, provided with a plain reduction gear so arranged that it

raises the propeller shaft and hub above the center line of the engine. There was sometimes an objection advanced against this arrangement to the effect that with the propeller eccentrically placed, even cooling of the cylinders is difficult. This does not appear to be so in the present case. A special type of cowling is being developed for this engine.

The induction system of the Pobjoy "R" is somewhat unusual and consists, as will be seen from Fig. 1, of a "spider" in which all the induction pipes are of the same length and symmetrically arranged. In the center they meet in a common exhaust-heated "hot spot" which is fed by a single-barrel carburetor. The inlet manifold forms the back cover of the crankcase, and is warmed by the hot oil.

The main data relating to the Pobjoy "R" engine are as follows: Seven cylinders, air-cooled, bore 77 mm., and stroke, 87 mm.; total swept volume, 2835 cc.; normal power and crankshaft speed, 75 b.hp. at 3000 r.p.m.; normal airscrew speed, 0.47 crankshaft speed, or 1400 r.p.m. at normal revolutions; normal b.m.e.p., 113.5 lb. per sq. in.; normal oil consumption, about 1 pint per hr.; maximum permissible power for 10 min., 85 b.hp. at 3300 r.p.m.; total engine weight, 130 lb. (59 kg.); specific weight (on normal power) 1.73 lb. per hp.; overall diameter, 25½ in. (647 mm.). (*Flight*, vol. 23, no. 23/1171, June 5, 1931, pp. 496–498, illustrated, *d*)

## ENGINEERING MATERIALS

### Workability of Killed and Open Steel

THE TERMS "killed" and "open" steel are used to designate two kinds of steel products today. Killed steel is a steel so well degasified in the furnace (open-hearth or electric) that when poured into ladles it lies still. In the case of open steel a large proportion of the gases is not removed, with the result that when the steel is poured into the ladles there is a boiling, with consequent evolution of sparks and flame for periods varying from 10 min. to ½ hr. Open steel is also known as "effervescent" or "rimmed" steel.

At the Kaiser Wilhelm Institute for Iron Research in Düsseldorf an investigation was made concerning the effect of deoxidation and degasification of steel on its properties. Six types of steel were produced: No. 1 which was deoxidized by manganese, killed by aluminum, and provided with silicon to the extent of 0.2 per cent. No. 2 was made in the same manner, except that aluminum was not used. In No. 3 the bath was deoxidized by manganese and killed with silicon. In No. 4 it was deoxidized by silicon, after which 0.2 per cent silicon was added. No. 5 was deoxidized with aluminum and 0.1 per cent aluminum remained in the steel. No. 6 was merely deoxidized by manganese. Some of the ingots were rolled into bars and some drawn into wire, while others were rolled into strip and normalized. Rupture tests have given good results in all cases, but the ratio of elastic limit to tensile strength was low in melts Nos. 5 and 6. Physical tests have provided sufficiently conclusive data as to the workability of the different materials.

The general conclusion arrived at is that open steel works better, although the difference between the two kinds is small. It was established that steel with a rough surface works better, probably because it lubricates better than steel with a very smooth surface. As a result of the investigation it has been found that, in general, in working steel the factors primarily affecting the results are the velocity with which the deformation is carried out, the shape of the working tool, and the character of lubrication, while the origin of the steel is comparatively unimportant. (P. Bardenheuer in *Stahl und Eisen*, vol. 51, no. 21, May 21, 1931, p. 651, *g*)

### Rate and Limits of Strain Hardening of Plastic Materials

THIS is the second of a series of articles dealing with plastic metals. The author points out that it is essential that cold working should not go beyond the limit of plasticity; at the same time, however, it increases the elastic limit and the yield point.

The author derives the following formula for computing operations:

$$r = \frac{S_2 - S_1}{S_x - S_1} \quad [1]$$

or

$$S_2 = S_1 + r(S_x - S_1) \quad [2]$$

in which

$r$ = per cent reduction in the particular operation, expressed as a decimal

$S_1$ = theoretical initial yield point, lb. per sq. in.

$S_2$ = final yield point or unit stress, not taking into account possible pyramiding of pressure in closed dies or because of relatively thin material

$S_x$ = theoretical extreme stress, which also designates rate of strain-hardening, since:

$$\frac{S_x}{1.00} = \frac{S_1}{R_1} = \frac{S_2}{R_2} \quad [3]$$

in which $R$ is the corresponding absolute percentage of reduction expressed as a decimal.

He gives an example of the calculation to discover the extreme unit stress in the flange of a shell during the last reduction.

An interesting part of the article is the discussion of the so-called plastic cycle. The metal may be required to traverse the plastic cycle a number of times in the course of its fabrication. Cold working strain-hardens it to the limit of its plasticity. Further working would then create fractures, internal or external, which only complete remelting could remove. Annealing must therefore be resorted to recrystallize the structure of the metal and restore its lost plasticity in preparation for the next operation. The plastic cycle is illustrated in the original article by curves referring to a 67:33 brass which had been strain-hardened by cold rolling to "spring" temper, annealed to restore its plasticity, and then cold worked by drawing to the same reduction and the same temper.

The author believes that the nominal "ultimate tensile strength" is neither a true ultimate nor a unit stress. The actual ultimate unit strength would be practically unchanged throughout the cold-work range, and would be much higher than the maximum nominal value. The latter is really an inverse measure of the remaining plasticity of the metal in any particular state. That is, the more the metal has been worked the less it will change in area before all slip planes are used up and fracture occurs. That means a larger final area and therefore a larger total load. As this increasing load is divided by the original area (a constant), the result is an apparently increasing strength. (E. V. Crane, Staff Engineer, E. W. Bliss Co., Brooklyn, N. Y. in *The Iron Age*, vol. 128, no. 8, Aug. 20, 1931, pp. 498–499, 543–545, illustrated, *g*)

## FUELS AND FIRING

### A Tangential-Firing Pulverized-Fuel System

THIS is a description of an installation of a gyro pulverizer at a plant in England. The pulverizer is of the high-speed beater type with the axis vertical. It is air swept in such a way that when coal particles of sufficiently small weight are

produced they are immediately blown away. With the pulverizer used on the unit system the pulverized coal is delivered direct to the combustion chamber, being admitted tangentially at high velocity (180 ft. per sec.) midway up a round or oval-shaped chamber, together with the primary air current and a proportion of the secondary air. The remainder of the secondary air is admitted also tangentially at the bottom of the chamber, where it is claimed to have important functions in relation to the ash. A vortex action is set up in the combustion chamber and the coarser particles of coal travel around a longer circumference than the smaller. A ball-like form of flame is produced that can be lowered or raised by controlling the air inlets. Only where the combustion is nearing completion is the full temperature developed.

About 70 per cent of the ash contained in the coal is said to be thrown out centrifugally to the side walls of the gyro chamber, where it adheres, slowly descending in a fluid, film-like state until a short distance from the bottom. Here the high-velocity secondary air meets it, breaks it up, and releases any carbon that may be imprisoned; the ash then falls to the bottom of the chamber in clinker, of formation like pumice stone. Typical ash is said to contain only a fraction of 1 per cent of carbon and to be cooled very effectively by the secondary air, which is thus heated to some extent. "Leolite" bricks, a product of the makers of the plant, are used as the refractory lining of the chamber; they have special slag-resisting qualities. It is claimed that after several weeks of firing, if the slag film is removed, the cleavage between slag and brickwork is so clean that the bricks have the appearance of having been newly laid; the abrasive action of the flame is taken by the slag film.

It is said that the makers of the device are prepared to guarantee boiler efficiencies, coal to steam, of 80 to 90 per cent. In most cases the total power consumed by the auxiliaries does not exceed 4 per cent of the output of the boiler. The pulverizer fan equipment requires between 7 and 11 kw-hr. per ton, depending on the size, moisture of coal, etc. The capital cost of applying the system to an existing boiler is given as approximately $5 per 15 lb. of steam generated per hour.

The article describes briefly an installation of the gyro pulverizer fitted to a 6000-lb. double-drum Babcock boiler, and another installation in India of two pulverizers connected with three single-drum Vickers boilers. (*The Power Engineer*, vol. 26, no. 302, May, 1931, pp. 172–174, 4 fig., *d*)

## INTERNAL-COMBUSTION ENGINES (See also Aeronautics: The Pobjoy R-Type Engine: Railroad Engineering: Diesel Locomotive With Invariable Drive)

### Status of Compression-Ignition-Engine Research

THE AUTHOR begins his account of the history of this research with the work done by the British Government during the World War, first at the Admiralty Engineering Laboratory and then under the auspices of the British Air Ministry, which latter designed and tested a light-weight compression-ignition engine operating at 1200 r.p.m. Research work upon this problem was thus undertaken in this country by the National Advisory Committee for Aeronautics, Pennsylvania State College, and others.

The great need of the industry at present is knowledge of the methods to be used in designing efficient injection systems and combustion-chamber shapes to cause a greater percentage of the air charge to take part in the combustion process and thus to realize the potentially high power output of the oil-engine cycle. Theoretically, a compression-ignition oil engine is capable of a higher power output than a gasoline engine, but means have yet to be found to achieve this.

The National Advisory Committee for Aeronautics has developed a spray-photography apparatus, and the penetration and other properties of oil jets have been examined, but a study of these tests and comparison with practical requirements indicate that their field of usefulness is rather restricted.

By way of illustration the author mentions the investigation of coefficients of discharge for small holes, and says that while interesting results have been obtained the diameters of the holes employed in these experiments are not small enough for a constant-pressure injection system and not large enough for a precombustion-chamber engine.

In a discussion which followed, A. M. Rothrock, of the National Advisory Committee for Aeronautics, pointed out, however, that orifices of 0.020 and 0.030 in. (i.e., of sizes within the range investigated by the N.A.C.A.) have been used successfully on high-speed Diesel engines with 5-in. and 5½-in. cylinders. Examination of the spray-phenomena data presented by the N.A.C.A. shows that diameters as large as these are necessary if penetration to a distance of about 4 in. is to be obtained in the short time available. Furthermore, results of Mr. Gelalles' work (not yet published) lead to the important conclusion that—with orifice diameters such as he investigated—0.008 to 0.025 in.—the coefficient of discharge is independent of the orifice diameter if the orifices are made geometrically similar and the flow through them is turbulent, or, if the flow is laminar, the Reynolds numbers for the conditions are the same. In connection with the more recent work of the N.A.C.A. dealing with fuel-spray research, considerable material has been published during the last two years in regard to orifices as small as 0.006 in.

The author does not believe that centrifugal sprays have been successful. A large amount of work with them has been done, but none has succeeded. Better results may be obtained through correct combination of combustion chamber, turbulence, penetration, etc. Here again reference will be made to the remarks of Mr. Rothrock in the discussion.

A clearer understanding of centrifugal sprays can be obtained by referring to the work of Dr. R. Kuehn, in addition to the work done by the Committee. He has shown that centrifugal sprays do not give, for equal injection pressures, better atomization than the sprays from plain orifices. Mr. Gelalles has shown that, with the same injection pressure, considerably less fuel is injected through a valve having a helically grooved stem than through one having a plain stem. Consequently, the centrifugal spray cannot be expected to give good engine performance unless used with much higher injection pressures or larger orifices than are required for plain sprays. The centrifugal sprays have not yet been given a fair trial. It can be said that centrifugal force does not improve the atomization of the spray, but it may improve the distribution.

As regards injection, the author believes that contact of unburned fuel with any metal surface must be avoided at all costs. Because of this, the jet travel between the nozzle and piston or wall is the limiting distance for complete combustion. In a normal, efficient combustion space for a 15-in.-diameter cylinder, the distance between the nozzle and the piston on the line of spray is not more than approximately 4 in. so that results such as 5 to 12 in. of travel before ignition are obviously off the mark. Ignition within a very small distance of the jet must be assumed to explain the combustion problem of a high-speed oil engine with any degree of satisfaction. If experimental results do not fulfil this condition, the apparatus and conditions should be analyzed to find the cause.

Dr. P. H. Schweitzer of Pennsylvania State College says, however, that precombustion chambers, hot plates, and piston

heads are regularly impinged upon by the fuel spray with no harmful effect. This is fortunate, because it is next to impossible to keep the fuel spray away from the piston. Many builders accentuate the impingement of the spray on the piston head. Krupp uses a mushroom impingement plate. Provision for spray impingement is also made in the Packard piston. Not many engines have been built in which the spray absolutely avoids hitting metallic surfaces. Most engineers are perfectly satisfied if the oil spray strikes no metallic surface which is cooler than, say, 1000 deg. fahr. Cracking, with carbon deposition on the surface, occurs in the range of approximately 700 to 1000 deg. fahr. Above the latter temperature, however, the carbon burns as soon as it is formed, and an impingement of the spray on such a hot surface is not objectionable. If this were not so it would be almost impossible to build Diesel engines in sizes less than 100 hp. per cylinder, because the spray is longer than the room available.

The subject of turbulence is taken up next, and the author tries to reconcile present conflicting views. Exponents of the turbulence theory usually aim for rotary air swirl at some definite rate which will distribute the fuel throughout the air in an efficient manner. Experiments conducted by the writer utilized various velocities of rotational swirl, and careful examination of the combustion chamber after tests failed to reveal any deflection of the oil jets. Very faint marks are usually visible upon the piston crown opposite the oil jets. It was possible to change these markings by quite a high rotary swirl from the position they occupied when no definite turbulence was attempted. It is quite possible that some dispersion of the finer oil particles occurred, but apparently the main body of the injection was undisturbed. Against this must be set the fact that Ricardo has demonstrated in no uncertain way that controlled turbulence can be relied upon for efficient combustion in a compression-ignition engine. He mentions the Ricardo single-sleeve-valve engine where the degree of rotational swirl at the end of the compression stroke was controlled by means of guides in the inlet port and a restriction in the combustion chamber. Heat turbulence increases the power output and fuel economy up to a certain value of the rotary swirl, but beyond this point the results fall off again, indicating that it is possible to cause excessive turbulence. He then refers to the Hesselman engine, the advantages of which he considers very doubtful.

Dr. Schweitzer thinks that the author seems to expect from the rotary air swirl something that the users of this method did not intend to obtain. It is well known that a strong oil jet is not deflected by a moderate wind. The purpose of the rotary turbulence is to bring fresh air to the fuel spray while the combustion is in progress. This is apparently achieved. Rotary turbulence has been used with good results, not only in sleeve-valve and two-cycle engines, but in four-cycle poppet-valve engines made by Hesselman, Krupp, De LaVergne, and others.

The characteristics of the three main types of engines are next considered, namely, the direct injection, precombustion chamber, and divided combustion chamber.

The popularity of the precombustion type of engine has undoubtedly extended its use far beyond its merits. It originated at a time when medium-speed and medium-duty engines were required and high-duty, high-speed oil engines were still considered almost an impossibility. Extensive research work resulted, particularly in Germany, in engines of the precombustion type. As a result, it has been far easier for companies unacquainted with the Diesel to extend this engine to higher speeds than to begin a design of their own, despite the demonstration by the Royal Aircraft Establishment of the far superior performance of the direct-injection system.

The low specific output results in abnormal size and weight for a given power, and it is considered that this engine has only very limited possibilities as an automotive engine, despite the fact that some modern engines of this class are operating at 2500 r.p.m.

Summing up the position with reference to the injection system, the author considers that for automotive purposes the compression-ignition oil engine of the future will be of the direct-injection type, or some modification of this, to secure the advantage of low weight per horsepower, easy starting in all weathers, wide fuel range, and high fuel economy. A four-cycle engine of this type should weigh 15 to 20 per cent more than an average gasoline engine operating at the same piston speed. If the two-stroke cycle is employed, as no doubt it eventually will be, its power-weight ratio will be superior to that of a gasoline engine.

Among other things, the author comes to the conclusion that there are as many right ways of applying turbulence as there are injection systems, each set of conditions demanding its own degree of turbulence, but that eventually the present great diversity of systems will gradually disappear and development will proceed along two or three well-defined lines.

The future compression-ignition engine for automotive applications will embody the direct-injection fuel system in its present or more probably in some modified form that will contribute to the construction of an engine of high power output for a given weight. This weight should not be more than 10 to 15 per cent above that of a corresponding gasoline engine of the same class, and, as subsequent progress is made toward the utilization of the air content of the cylinder, the weight per horsepower of an oil engine should trend toward being less than that of the present gasoline engine.

Production of high-speed, high-duty compression-ignition engines will make the question of detonation more prominent than it has been, and here is a wide field, now almost unbroken, for the research worker. (E. T. Vincent, Diesel Research Engr., Continental Motors Corp., Detroit, Mich., in *S.A.E. Journal*, vol. 28, no. 6, June, 1931, pp. 642–647, 4 figs., and discussion on pp. 647–652, 3 figs., *cg*)

## MACHINE-SHOP PRACTICE

### Boring and Honing Seamless Steel Tubes

IN HYDRAULIC systems it is greatly desirable to hold leakage to a minimum and to do this it is necessary to have cylinders and pistons possessing a high degree of accuracy. Long ago the problem was solved for pistons, but the matter of cylinders is somewhat different. In hydraulic equipment manufactured by the Oilgear Company, Milwaukee, Wis., the cylinders are honed to size within 0.0005 in. and similar accuracy is specified for parallelism and out-of-roundness. The material from which the cylinders are made is seamless steel tubing of standard thicknesses in sizes of from 1.5 to 7.125 in. and of length varying from 3 ft. and under to as long as 15 ft. The first step in finishing the inside of the cylinders is to bore them to an approximate size. In this case use is made of a cylindrical cutter head that guides itself on the surface finished by an inserted high-speed-steel blade. This blade is ground to a radius on top directly in back of the cutting edge and ground to an angle along the front for clearance. The blade is relieved at the end that starts the cutting so that the cutting increases gradually in depth as the blade enters the tube. The method of holding the tubes accurately in place for boring is described. The cylinders are honed in the lathe illustrated in the original article and provided with a special carriage reciprocated hydraulically. A spring-type hone is mounted on the front end of a sturdy bar attached

to the carriage. A universal connection is provided for the hone so that it can follow the bore produced in the preceding operation. The hone is set to approximately the prescribed cylinder diameter at the beginning of the operation, and expands automatically to this setting as the cylinder bore is honed away.

During the honing the work is revolved at 80 r.p.m. and the hone is traversed at the rate of approximately 90 ft. per min. The length of hone traverse is governed by means of stops which operate a combination valve when the carriage reaches the extreme points of its stroke. Kerosene is used as a lubricant between the hone and the cylinder. Measurements are taken at intervals by means of internal micrometers for the purpose of determining the size of the cylinder at different points along its length.

The high degree of finish attained in honing the cylinders is attributed by the concern in a large measure to the fact that the hone is reciprocated hydraulically. The cylinder and piston that operate the hone carriage are located between the bed ways directly in the center of the machine. The cylinder is of the 2-to-1 differential type and is used in combination with a three-way circuit that provides equal carriage speeds in both directions. (*Machinery*, vol. 38, no. 1, Sept., 1931, pp. 9–11, 4 figs., *d*)

## MACHINE TOOLS

### Report on Machine-Tool Trade With Russia

THIS report received from a special representative of machine tools deals with Russian market possibilities for shop equipment. During 1930 American manufacturers sold industrial equipment to Russia amounting to about $40,000,000, and of this nearly three-quarters went for machine tools and shop equipment.

The author points out that the machine-tool business prospects are not tied up in any difficult way with the five-year plan, because even after the termination of the five years and completion of the plan there will be a demand for machine tools to satisfy the requirements of the population and Russian factories will not be able to supply it.

The organization for the purchasing of machine and small tools and mechanical equipment was originally known as Metallo Import, but has since been broken up into several divisions. Orga Metall is the demonstration and show room for all foreign machine tools and production equipment. Stanko Import carries on negotiations for the supply of machine tools, small tools, jigs, fixtures, precision apparatus, furnaces, etc. Metallo Import proper is concerned with the purchase of heavy machinery, metallurgical equipment, presses, power hammers, boilers, engines, cranes, etc. Elektro Import deals with electrical machines and equipment. One of the most interesting of these is the Orga Metall department in Moscow. The main area is devoted to a demonstration hall in which are installed, under working conditions, examples of all machines and other equipment sent by American, English, German, French, and other manufacturers. Here the machines may be inspected by works directors, managers, and engineers from all over the Soviet Union, and the ultimate selection of equipment will depend greatly upon the inspection and demonstration here made and given. It cannot be too strongly impressed upon manufacturers of machine tools and works equipment who would do business with the U.S.S.R., that this department is of basic importance.

The Orga Metall organization, important as it is, does not eliminate the necessity of making a direct approach to the executives and engineers of the individual plants, and it is advisable, and even necessary, that direct contact be made by members of sales organizations of firms supplying machines and production equipment.

Firms must be lavish with the literature of their products in the Soviet Union and see to it that works directors, works libraries, and libraries of the controlling organizations and Orga Metall are well supplied. If the literature is printed in the Russian language, so much the better. Some of the higher executives read, if they do not speak, English, but more appear to know and use German.

The aim of Orga Metall is to have all machines installed under running conditions, ready for instant demonstration to works visitors. It is highly important, therefore, to send out samples of work or parts produced by the machine, together with necessary work-holding and tool equipment. Some of the German manufacturers provide neat and attractive glass show cases to contain the work specimens. Also, it is important to send a set of spare replacement parts in case of breakage.

The charge made for installing a machine in the Orga Metall demonstration department is $7.50 per sq. m. (10.764 sq. ft.) of floor space occupied per six months. No charge is made for show cases, show cards, or pictures of works. Every machine must be tooled up free of cost, and it is desirable, in the first instance, to send over a demonstrator.

Important information is given in reference to the machine-tool industry and the small-tool industry in Russia. Only engine lathes and machines of simple type are at present being produced, and even under the new development scheme the building of elaborate and expensive machines is apparently not to be undertaken.

The two big factories under construction, namely, Frezer and Kalibr, are designed to fill the requirements of Soviet industry in respect to milling and other cutters, jigs, fixtures, and control apparatus. They will employ 12,500 people.

Output incentive is supplied by groups of what are termed "shock brigades" and "shock workers." These consist mainly of young and enthusiastic people—communists—who, earnest of purpose in bringing to success the five-year plan, set the "tempo," fire the less efficient with the spirit of emulation, and encourage them to a more intense effort.

Department competes with department and factory with factory, the relative output and progress being depicted almost daily on wall charts or wall newspapers, often graphically and in an amusing manner.

Workers reach the "shock" status on the double basis of quantity and quality output. They occupy a "top of the class" position in the factory, and gradual improvement means a shifting of seat or bench until the shock position is reached. In the Lepsa electrical works, for example, the girls in the stator-winding department are on piecework and earn from 120 roubles up to "shock" rates of 170 roubles per month. The quality of work is indicated by the percentage of rejects, which overall in the department is 1 per cent and in the case of the shock brigade itself, one-quarter of 1 per cent. The "Young Communist" shock brigade at these works has just been awarded the highest honor conferred by the Soviet Republic for finishing the five-year plan in $2^1/_2$ years.

Information is given as to the number of men employed in the more important machine-tool plants, and in addition brief data on the new Soviet standard lathe of which 6000 are scheduled to be produced in 1933. This lathe, of which illustrations are given in the original article, follows very closely the design of the German standard machine and will be built in three sizes. (C. Edgar Allen, Director, Machinery Publishing Co., Ltd., in *Machinery*, vol. 38, no. 1, September, 1931, pp. 49–54, illustrated, *sd*)

## MECHANICS

### Mechanism of the Atomization of Liquids

A DISCUSSION is given of the general problem and of some applications of the phenomena of liquid atomization, with especial reference to fuel preparation in internal-combustion engines. It is pointed out that both "air" and "solid" injection seem to have physical backgrounds quite similar to that of airstream atomization, and the discussion is limited to the latter.

Some previous work which seems to bear either directly or indirectly on this problem is reviewed, and it is assumed that a necessary step in atomization is the tearing of ligaments from the unatomized mass, these ligaments being of such sizes that they will eventually break up into drops of the sizes observed in the spray.

Brief discussions are given of the applicability of Rayleigh's work on the rate of collapse of liquid columns to the collapse of these ligaments, and of what values of the length/diameter ratio and of the degree of instability may be expected to be effective. It is then shown how the sizes of the ligaments can be determined from those of the drops in the spray. Finally, combining measurements of the sizes of drops, it is shown that these ligaments will collapse so quickly at sufficiently high air speed—that is, when true "atomization" sets in—that the droplets will then appear to be picked directly from the main mass, as has been observed.

The conclusion to which the author comes is that the actual process of atomization in an airstream seems rather simple: A portion of the large mass is caught up, say, at a point where its surface is ruffled by the air stream, and, being anchored at the other end, is drawn out into a fine ligament. This ligament is quickly cut off by the rapid growth of a dent in its surface, and the detached mass, being quite small, is swiftly drawn up into a spherical drop. A quite similar phenomenon occurs when a large drop is detached from a tube. The chief difference is that the ligament connecting the small drop to the main mass is much finer than that connecting the large drop to the liquid in the tube, and hence the time of detachment is enormously less. The higher the air speed, the finer the ligaments, the shorter their lives, and the smaller the drops formed, within the limits discussed above. (R. A. Castleman, Jr., in *U. S. Bureau of Standards Journal of Research*, vol. 6, Mar., 1931, Research Paper No. 281, pp. 369–376, and 3 plates of illustrations, *et*)

## METALLURGY

### Electric Power in the Steel Industry

IT WAS electrification that made continuous strip rolling attractive to steel mills. Strip usually covers a range from 3 to 20 in. in width, while sheet varies in width from 30 to 60 in. Since the continuous type of individual motor-driven mills has proved so successful in strip mills, it is only natural that present-day production of heavy sheets is being drastically changed. The transition has not reached that same conclusive state as it has in strip mills, and at the present time only the heavier sheets are being rolled on this type of mill. It is possible, however, that in the near future the continuous rolling of sheet will be almost as complete as the continuous production of strip.

From sheet to plate is the next logical step; consequently the first installation of a continuous plate mill is being made now. In other words, the use of the tandem mill motor specially designed for flat speed regulation has gone from strip to sheet mills and now is invading the plate-mill field. In general, the old type of mill was able to produce from 10,000 to 15,000 tons per month.

Recently with the development of structural shapes has come a new type of wide-flange mill where motor drive has been utilized. In the rolling of these larger and relatively more complicated shapes only the advent of sensitive, sturdy, and accurate automatic electrical-control devices has made the wide-flange mill an operating success. In one mill typical of this a 7000-hp. motor drives the main rolls (used on the web and inside flanges of a beam) and also two vertical rolls which reduce the outsides of the flanges. Adjacent in the line of production is a set of auxiliary horizontal rolls which reduce the edges of the flanges. These auxiliary rolls are driven by a 2000-hp. motor. It is essential that these two motors remain in synchronism regardless of the relative load on either of them. Also, with the material passing back and forth between these three sets of rolls and with the different drafts to be taken on the rolls, various speed relations between the three sets of rolls must be present and rigidly maintained for any given pass. This represented one of the difficult problems in the design of the electrical equipment for this mill. It not only required a careful designing of the control, but of the motor as well.

Ten years ago the electrified plant enjoyed an advantage of $2.50 per ton of product over a steam-driven plant; at present this difference is even greater. (G. E. Stoltz, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa., in *Electrical Engineering*, vol. 50, no. 6, June, 1931, pp. 410–411, 3 figs., *g*)

## POWER-PLANT ENGINEERING

### Ash and Dust Prevention and Separation in Boiler Plants

THIS is a review of the 23rd Report of the German Coal Dust Committee published by the publishing branch of the Verein Deutscher Ingenieure and being a symposium of six papers.

According to Meldau, the nature of the disposition of fine ash in the neighborhood of the smokestack is determined by such factors as the contour of the ground in the neighborhood, the prevailing winds, the moisture in the air, and the amount of rain or snow. Methods of measuring or sampling the dust are considered. Among other things, the investigators have traced the dust from certain boilers by mixing small quantities of cobalt or other coloring matter with the coal when it is being pulverized. The material colors the molten portion of the ash, and enables it to be easily detected when examined by polarized light under a microscope.

Otte points out that boiler designers should endeavor to have the maximum amount of ash deposited in the boiler itself, and to direct such deposits into specially designed bases through which they can be removed. Consideration is given to the problem of bringing the ash as rapidly as possible to the melting point so that it can be deposited in the combustion chamber before coming into contact with the cooling surfaces.

For the dividing out of the remaining ash in the flues of the boiler in such a manner as to obviate the choking up of the passages, and the covering of the heating surfaces, and yet arrange for the deposition into suitable chambers, special design is necessary. For this purpose further chambers are erected under the heating surfaces outside the main gas stream and still in the region of the hot gases. The latter point is important, as it has been proved that the separation of the dust in the hottest zone gives the best results, and that the dust falls more easily from gases at from 900 deg. to 1000 deg. than at, say, 200 deg. or lower.

The author examines recent trends of design and points out that in water-cooled boiler furnaces, because of the high temperatures, the ash is brought to the melting point and deposited on the inside walls and then falls into the lower chamber as rapidly as possible. In modern burners the products from the burner are directed almost horizontally rather than as formerly at a downward angle of 45 deg. This arrangement with the

use of highly heated air results in the attainment of maximum temperature and therefore the most favorable condition for the melting of the solid particles.

The matter of flue design is considered next.

Rammler attempts to find out from the experience which German engineers have had with the coal-dust problem in the briquet factories what could be done in dealing with the problems of dust separation in boiler rooms. He comes to the conclusion that the technical difficulties are no greater in the one case than in the other, apart from chemical action of boiler flue gases. The economic question is, however, highly important. In another of his papers the same author states that a plant which is correct and economically usable for the "capital rich" lands of America, France, and England, may not be suitable for the "blood poor" land of Germany. The problem is not a new one, but engineers prefer to work on perfecting and cheapening known designs rather than seek new methods of advantage. He does not believe that cyclone plants are suitable for large power installations using pulverized fuel.

He next deals with dust separators in which vertical corrugated plates are placed in the flues in the path of the horizontal moving gases. The dust meeting these corrugations loses its velocity and finally drops to the lower edge of the plates into suitable dust receivers. In one form of these separators the edges of the plates are pointed and electrostatically loaded, so that one obtains an electromechanical filter, which, it is claimed, causes high-grade separation. In the author's opinion, while such a filter has a high efficiency, it is costly to install, and involves high power for the moving of the gases on account of the winding passages through which they have to pass. Further, one would imagine that the life of the plates must be of short duration.

The engineers of the Hanover Steam Boiler Superintending Company discuss the use of the electric filter and give comparisons of the relative first costs, running costs, and efficiencies of the cyclone and electric separators, from which it appears that for equal requirements the electric plant is 50 per cent higher in first cost, and has a slightly higher efficiency and approximately the same running cost, including interest and depreciation. It is interesting to note that for a case investigated by the above officials electric separators were advised. (23rd Report of the German Coal Dust Committee, abstracted through *Engineering and Boiler House Review*, vol. 44, no. 11, May, 1931, pp. 710–712, 714 and 716, *g*)

### Comparative Tests of a Gas-Driven Generator Set and a Steam-Driven Alternator Set

IN THIS case the test was made to determine the relative economic efficiencies of two sets of generating units—one a M.A.N.-Schneider gas-driven generator of 5200 kw. capacity; and the other an A.E.G. (German General Electric Co.) steam-driven alternator set of 6000 to 9000 kw.

The gas engine was of the D.T.Z. type, double-acting, four-stroke cycle, with scavenging and supercharging. The engine cylinders were of 1350 mm. (53.15 in.) bore and 1400 mm. (55.12 in. stroke, running at 91 r.p.m. with a compression ratio of 5.05. The motor is rated at 7250 effective horsepower in continuous operation, and is guaranteed by the builders to show at full load a specific consumption of 2000 kg-cal. (7936 B.t.u.) per i.hp-hr., assuming that the heat content of the gas is not less than 900 kg-cal. per cu. m. (100 B.t.u. per cu. ft.). The mechanical efficiency of the motor at full charge is rated at 86 per cent. The charge is increased by the injection of air under pressure at the end of the exhaust stroke and supercharging at the beginning of the compression stroke. The gas engine works in combination with two recuperative furnaces.

The steam unit consists of a single turbine having six wheels and six regulating valves, and running at 3000 r.p.m. The steam at the admission valve has a pressure of 18 kg. per sq. cm. (256 lb. per sq. in.) and a temperature of 375 deg. cent. (707 deg. fahr.).

The author considers in detail the features of operation of the two units and comes to the conclusion that from the thermal point of view alone the gas engine is superior to the steam turbine, at least within the sizes and of the types used in the present comparison, these being exactly the sizes and types common in metallurgical plants of France.

The specific fuel consumption for the two types is given in the form of curves in the original article, and is somewhat higher for the steam engine. Other factors must be, however, taken into account. The article is of interest because of the many curves of operation which it contains. (Marcel Steffes in *Chaleur et Industrie*, vol. 12, no. 131, March, 1931, pp. 103–108, 15 figs., *c*)

## RAILROAD ENGINEERING

### Diesel Locomotive With Invariable Drive

BY INVARIABLE drive is meant here a locomotive in which a Diesel engine drives direct to the axle without an intermediate transmission which permits varying the axle speed independently of the engine speed.

One of the greatest difficulties in the way of accomplishing such a drive on Diesel locomotives is the problem of starting. After an extensive discussion of the subject and comparison of the various features of operation of the Diesel engine with those of the steam engine, the author proposes what he claims to be a new solution which is essentially, as follows:

Ignition of the fuel in a Diesel engine is produced by injecting it into air, the temperature of which is higher than the temperature of ignition of the fuel. Just how the air in the cylinder is heated to that temperature is essentially immaterial. In the conventional Diesel process this heating of the air is produced by its compression, but at low piston velocities a part of the heat is lost through conduction of the piston and part of the heat of compression is lost due to the excessive length of the compression process, with the result that, particularly in the case of a cold engine, ignition may fail to take place. Should the cylinder in some manner or other be supplied with hot air then the ignition process would take place no matter how low the piston velocity might be. In fact, it would take place with the engine standing still, just as happens in the case of dust bombs.

One might take preheated air by suction from the main engine as is now being done in tar-oil Diesel engines, or the hot air might be supplied to the engine before the beginning of the compression stroke. This would not eliminate completely the necessity for some kind of a starting device, although it would limit the range of its application. If, however, the main engine were supplied with hot air at the end of the compression stroke, the hot air being under such a pressure that at least the necessary starting torque could be developed, then all that would be necessary would be a small compressor to deliver this compressed air. A locomotive operating along these lines would have to be built something like this.

The main working cylinders would be driving direct to the driving axles and would be arranged in exactly the same way as the same cylinders of steam locomotives of similar design, and they would have approximately the same cylinder volume. The maximum combustion pressure need not be more than the starting-air pressure. This latter would be produced in an auxiliary plant and heated to about 350 deg. cent. (662 deg. fahr.) in a preheater fed by exhaust gases from the auxiliary engine. The compressor and preheater would in no essential

way differ from those now used on the Essling Diesel compressed-air locomotive. Their dimensions are so proportional that at about 6 km. per hr. it is possible to operate the locomotive on straight air, and the same applies in switching. As soon as hot air has been admitted to the working cylinders, which have been already preheated by the circulation of the cooling water from the auxiliary engine, fuel can be admitted to the cylinders which makes possible "mixed" drive during the first few revolutions of the engine. When the engine has been thoroughly warmed up the compressed air may be cut off and the engine operated as a straight Diesel engine; or some compressed air may be added to the cylinders regularly, which will bring about the high-pressure loading, and which, in turn, will permit increasing materially the area of the diagram up to full pressure. With such an arrangement the maximum mean effective pressure can be raised to at least twice that of the conventional Diesel process; with an increase of velocity, however, a natural limit is set to this increase of pressure because of the heat load on the cylinder.

Naturally, the fuel cannot be supplied to the cylinders in the conventional manner, as it must be supplied slowly in order to change the present narrow and high diagram into a wide one without generally increasing the pressure. To accomplish this it will be necessary to develop ways of injecting the fuel intermittently in small quantities so as to maintain the injection pressure constant regardless of the revolutions of the engine. It is stated that a satisfactory design has been worked out (apparently on paper only) for a locomotive of 1400 hp. maximum output based on the German 2-C-1 design. (Prof. K. v. Sanden and Graduate Engr. H. Wohlschläge, Carlsruhe, in *Organ f. d. Fortschritte des Eisenbahnwesens*, vol. 86, no. 7, Apr. 1, 1931, pp. 167–171, 5 figs., *g*)

### On the Calculation of the Drawbar Pull of Steam Locomotives

AS A RESULT of tests made at the Oi Locomotive Testing Plant the following has been developed for determining the indicated horsepower and tractive effort at the driving wheels:

$$\text{I.HP.} = 0.165\ (W - 500\ n) \qquad (a)$$

$$Pd = \frac{K(W - 500\ n)}{V} - 200 \qquad (b)$$

where I.HP. = indicated horsepower; $W$ = steam consumption (kg. per hr.); $n$ = number of cylinders, $Pd$ = tractive effort at driving wheel (kg.); $V$ = speed (km. per hr.); $K = 44.55 \times (1 - 0.035\ D/l)$, and $D/l$ = ratio of driving-wheel diameter to piston stroke. (R. Nakamura, Research Office, *Japanese Government Railways, Tokyo, Bulletin*, vol. 19, no. 17, Apr. 25, 1931, 30 pp. in Japanese language, *e*)

## REFRIGERATION ENGINEERING

### Compound Compressors in the Refrigerating Industry

MULTI-STAGE compressors have been finding an increased application in the refrigerating industry, because they work more economically than single-stage machines and there is a smaller rise of temperature at the end of the compression period. Already in large installations with a compression ratio of 1:4.5 it pays to install a two-stage machine, even though the first cost is somewhat higher. The usual layout of a two-stage compressor with two-stage throttling and two-stage compression is shown in the original article. It is of particular advantage when cold has to be produced at two different evaporation temperatures. In such a case the intermediate pressure may be so selected that the amounts taken in by suction by the low-pressure cylinder and the high-pressure cylinder are equal, with the result that a standard double-acting compressor can be used with separate suction and pressure piping for each half of the cylinder. In the carbon dioxide compressors the same simplification can be attained by making the head end the low-pressure stage and using the other half of the cylinder—somewhat reduced in volume by the presence of the piston rod—as the high-pressure stage. A disadvantage of this arrangement lies in the fact that the piston-rod gland must be packed against the pressure of the high-pressure side.

The design of compound compressors puts new problems up to the engineer. The present article describes the solutions found by the firm of A. Borsig, Berlin-Tegel, Germany.

As far as possible, parts of single-stage compressors which the firm was already building were incorporated in the design of the compound compressors. These parts included frames, cylinders, drives, lubricating systems, flywheels, and outboard bearings. This simplified the construction and saved considerable time and money.

While theoretically each modification of the temperatures of condensation and evaporation effects a change in the cylinder ratios, which would necessitate an infinitely great number of combinations of high- and low-pressure cylinders, it was actually found possible to standardize compound compressors. An illustration in the original article shows a large single-stage compressor from which all the main parts, with the exception of cylinder and pistons, were taken to build a compound compressor, likewise illustrated in the original article. Like the original single-stage compressor, the compound compressor is of the double-acting type, the low-pressure cylinder being placed in the middle, while the high-pressure part consists of two cylinders, one at each end of the low-pressure cylinder.

Another advantage of this design lies in the fact that the rear high-pressure cylinder can be easily removed for changing the piston rings, and the piston can also be withdrawn easily.

Fig. 2 shows the coning of the ends of the low-pressure cylinder, which is claimed to have the advantage of reducing the clearance space in the low-pressure part.

The suction valves are provided with a screw-down arrangement which permits starting the compressor unloaded and reducing the output to any desired extent. The location of the valves on the periphery of the cylinder makes it possible to install several valves.

While for large units this type of compound compressor was found to be satisfactory, for small units the single-acting type shown in Fig. 3 is preferable. Here the size of the piston areas is also determined by the requirement that the distribution of forces shall be the same in both directions of the stroke. It is true that variations of condenser pressure can produce a certain lack of uniformity, but this, it may be said, is scarcely noticed in the higher-speed machines.

The space between the high- and low-pressure parts formed by the rear side of the low-pressure piston is connected to receiver, as a result of which an average pressure prevails in this part of the cylinder all the time. The advantages of this single-acting type lie in the fact that both the cylinders and the pistons for the low- and high-pressure sides can be respectively made in a single piece. The manufacture of the two-stage piston can be therefore carried out as simply as in the case of a standard single-stage compressor. In the case of very low evaporation temperatures, namely, those lying below —50 deg. cent. (—58 deg. fahr.), the question of a further subdivision of the pressure ratios again arises, as in two-stage compression excessively high final temperatures are apt to occur and the advantages of compound compression are not sufficiently appreciated.

In the case of an $NH_3$ compressor with evaporation at —50 deg. cent. (—58 deg. fahr.) and a standard temperature of condensation

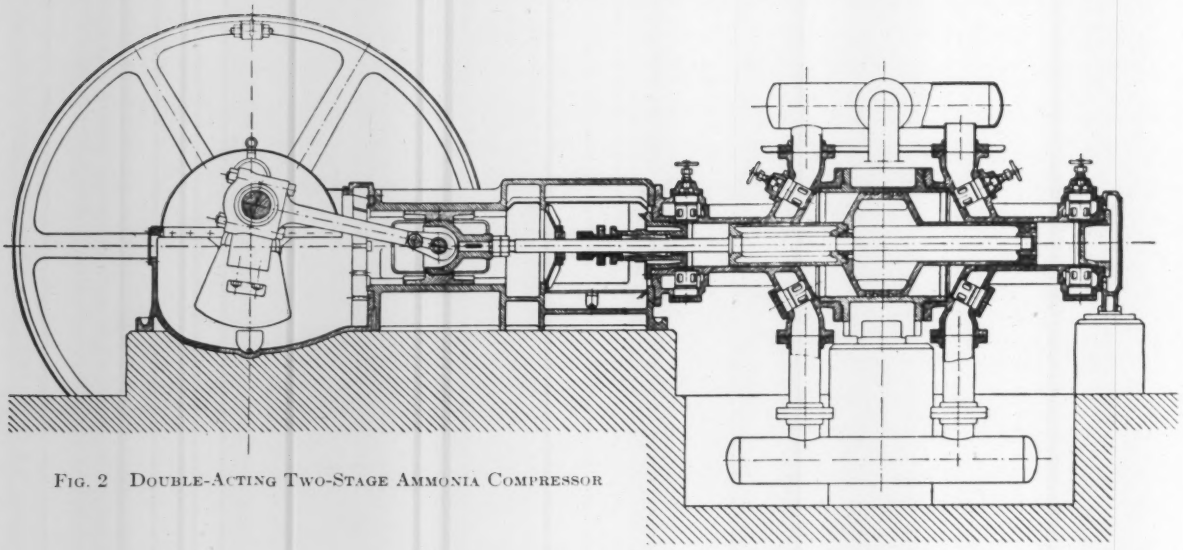

FIG. 2 DOUBLE-ACTING TWO-STAGE AMMONIA COMPRESSOR

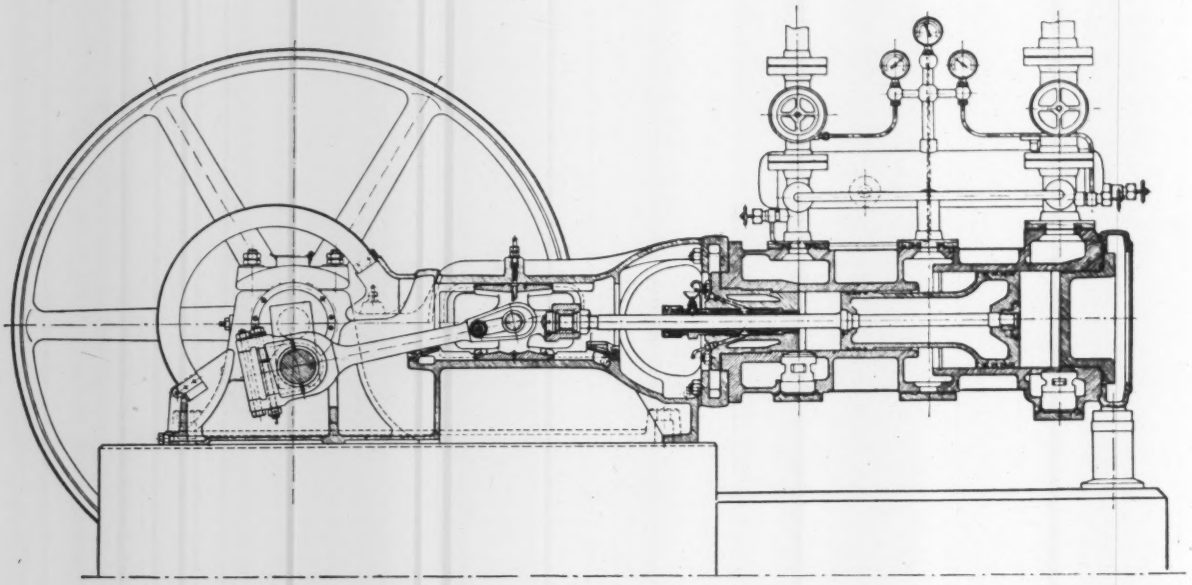

FIG. 3 SINGLE-ACTING TWO-STAGE AMMONIA COMPRESSOR

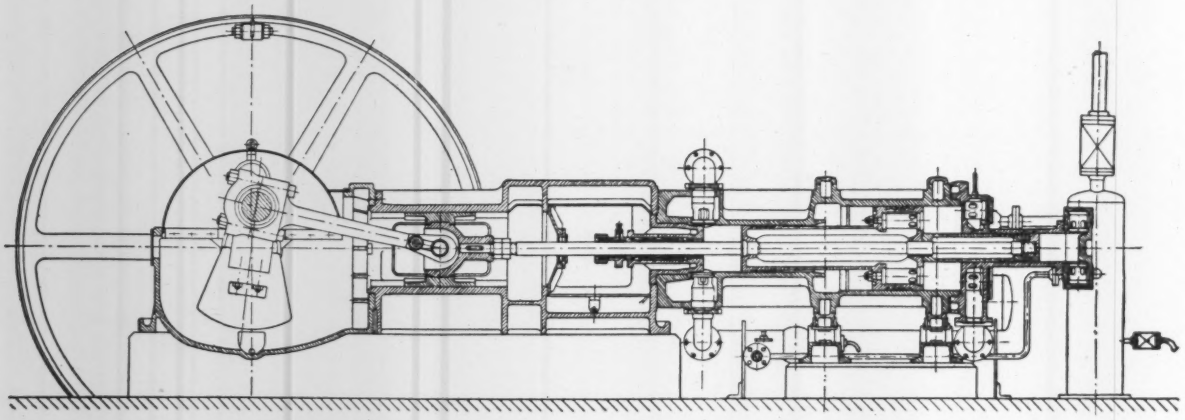

FIG. 4 SINGLE-ACTING THREE-STAGE AMMONIA COMPRESSOR

of + 25 deg. cent. (77 deg. fahr.) the total ratio of pressures was found to be 1:25. Because of this, —50 deg. cent. (—58 deg. fahr.) can be considered as the lower limit for the application of two-stage compressors. For temperatures below that three-stage compressors would have to be employed, and the design features of such a three-stage compressor are shown in Fig. 4. As the pistons are single-acting, a sufficient number of suction valves of adequate size can be located in the large low-pressure piston. The pressure valves have plenty of room in the annular surfaces between the low-pressure and the high-pressure sides. At very low temperatures the pressure in the low-pressure stage may be below atmospheric, in which case there is danger that outside air will enter. To prevent this, in the case of ammonia

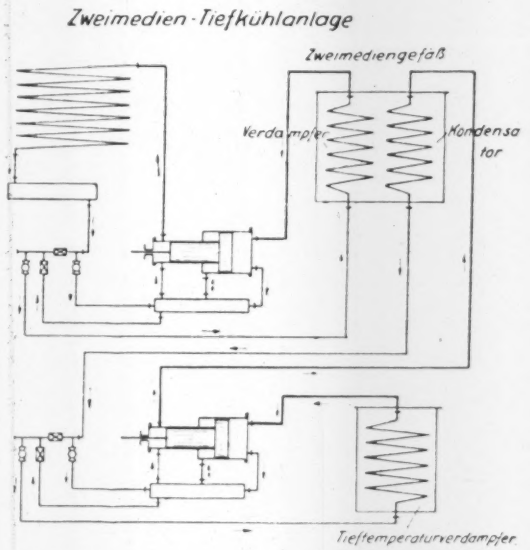


FIG. 5 BINARY-FLUID LOW-TEMPERATURE REFRIGERATING UNIT (*Zweimediengefäss* = Binary-fluid vessel; *verdampfer* = evaporator; *kondensator* = condenser; *tieftemperaturverdampfer* = low-temperature evaporator.)

compression the bearing gland should not be placed on the low-pressure side.

The question arises as to the lowest possible evaporation temperature in a refrigerating plant. Carbon dioxide freezes at —56.5 deg. cent. (—69.7 deg. fahr.) while the triple point for ammonia is at 77.9 deg. cent. (—108.2 deg. fahr.) which means that —70 deg. cent. (—94 deg. fahr.) may be considered for all practical purposes as the lowest evaporation temperature for ammonia.

The chemical industry, however requires much lower temperatures, and for such purposes where temperatures are required in the region of —100 deg. cent. (—148 deg. fahr.) resort is made to binary-fluid refrigerating machines.

In such machines the total temperature range of, say, —100 deg. cent. (—148 deg. fahr.) at one end and +25 deg. cent. (77 deg. fahr.) at the other, is divided over two units. One of these units operates at —100 deg. cent. (—148 deg. fahr.) in the evaporator and the other at —40 deg. cent. (—40 deg. fahr.) in the condenser. The other plant, using ammonia as the cooling medium, works with the temperature of evaporation of —50 deg. at the task of carrying off the heat which comes from the evaporator at —100 deg. cent. (—148 deg. fahr.) and consists of the heat equivalent of the compressor work in the low-temperature stage and the radiation losses.

Fig. 5 shows the two interlinked circuits working with different cooling media. Each unit operates double-stage. In the binary-fluid vessel is located the condenser of the low-temperature unit and also the evaporator handling the higher temperature of the other unit. As refrigerating media for evaporation temperatures of the order of —100 deg. cent. can be used ethylene ($C_2H_2$), ethane ($C_2H_6$), methane ($CH)_4$, nitrogen monoxide ($N_2O$), and certain other substances which at these low temperatures have a sufficiently high pressure to prevent air from entering the system. In the selection of an appropriate cooling medium the explosion danger has to be carefully considered. Among the illustrations included in this article are those of an ammonia marine compressor with separate cylinders for high and low pressure, as well as a vertical carbon dioxide twin-compound compressor built for the German refrigerated motorship *Volkswohl*. In this latter the cylinder, because of the high pressure employed, is made out of a forged steel block. (Engr. Hans Freund, Berlin-Tegel, in *Zeitschrift für die gesamte Kälte Industrie*, vol. 38, no. 4, April, 1931, pp. 50–55, illustrated, *d*)

## VARIA

### Professional Fees

THE APPENDED schedule of commissions, fees, and charges has been adopted for the use of members of the Victorian Institute of Engineers.

GENERAL FEES AND CHARGES

| | | | |
|---|---|---|---|
| Consultations, calculations, reports, etc., including time in traveling and attendance at courts of law, per day | £ 10 | 10 | 0 |
| First assistant's time, per day | 4 | 4 | 0 |
| Draftsman's time, per day | 2 | 2 | 0 |
| Minimum charge for consultation | 5 | 5 | 0 |
| Acting as arbitrator or umpire, per day, exclusive of out-of-pocket expenses | 15 | 15 | 0 |

All out-of-pocket expenses incidental to the service to be added to these charges. Day—not more than six hours.

EXAMINATIONS, VALUATIONS, AND REPORTS

(*a*) For examining drawings, and specifications, or the valuation of land or buildings, or inspecting and reporting on structures or both, for mortgage or otherwise, and certifying for advances, the charge shall be for the first £10,000, one-half of one per cent, and for the remainder one-tenth of one per cent of the estimated value.

(*b*) Measuring, bringing to account the valuing work done, $2^1/_2$ per cent upon the gross amount of the account.

(*c*) Valuing of plant and machinery, 1 per cent on amount of valuation.

PERCENTAGE FEES (£ 1000 to £ 10,000)

| | Per cent |
|---|---|
| Estimates only | $2^1/_2$ |
| Estimates and preliminary plans | 5 |
| Plans, specifications, and supervision | 10 |

Thereafter, the minimum payment to be made for an engineer's services shall be 6 per cent of the total cost of the works executed from his designs, except as mentioned elsewhere.

On all works on which the expenditure is mainly for special or skilled labor rather than for materials, the engineer's charge may be increased in accordance with the special circumstances and conditions of the case.

In case of works for which a higher rate than the above is chargeable for full services, the foregoing proportions of such higher rate shall be charged where the works are not subsequently carried out by the engineer. (*The Commonwealth Engineer*, Melbourne, Australia, vol. 18, no. 9, Apr. 1, 1931, p. 315, *g*)

# Instruments and Apparatus

## Preliminary Draft of Part 12—Measurement of Time

**The Main Committee on Power Test Codes takes pleasure in presenting to the members of the Society for criticism and comment Part 12, Measurement of Time. The Individual Committee which has developed this draft consists of Messrs. C. F. Hirshfeld, Chairman, W. A. Carter, Secretary, C. M. Allen, E. G. Bailey, L. J. Briggs, C. R. Cary, J. D. Davis, R. E. Dillon, F. M. Farmer, J. B. Grumbein, W. H. Kenerson, E. S. Lee, E. L. Lindseth, O. Monnett, S. A. Moss, R. J. S. Pigott, E. B. Ricketts, and W. A. Sloan.**

**The "Instruments and Apparatus" Section will consist of twenty-one parts dealing with the following subjects: (1) General Considerations,[1] (2) Pressure Measurement (6 chapters),[2] (3) Temperature Measurement (9 chapters),[3] (4) Head Measurement, (5) Measurement of Quantity of Material, (6) Electrical Measurements, (7) Mechanical Power, (8) Measurement of Indicated Horsepower, (9) Heat of Combustion, (10) Flue-Gas Analysis, (11) Determination of Quality of Steam,[4] (12) Time Measurements, (13) Speed Measurements,[5] (14) Mechanical Measurements, (15) Surface Area, (16) Density Determinations,[6] (17) Determination of Viscosity of Liquids,[4] (18) Humidity, (19) Concentration of Dilute Solutions, (20) Smoke-Density Determinations, and (21) Leakage Measurements (2 chapters).[7]**

**Complete copies of the draft, which is published here in abstract, may be obtained from the Society's headquarters. The Individual Committee, the Main Committee, and the Society will welcome suggestions for corrections or additions to this draft from those who are especially interested in this subject. These comments should be addressed to the Chairman of the Committee, in care of The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y.**

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[1] See pamphlet published in June, 1928.

[2] Chapter 1 of Part 2, on "Barometers," and Chapter 6 of Part 2, on "Tables, Multipliers, and Standards for Barometers, Mercury and Water Columns, and Pressure Measurements," were both published in pamphlet form in June, 1929.

[3] Part 3, Chapter 1, "General," Chapter 5 on "Pyrometric Cones," Chapter 6 on "Liquid-in-Glass Thermometers," and Chapter 7 on "Bourdon Tube Thermometers," were published in pamphlet form in March, 1931.

[4] See pamphlet published in January, 1931.

[5] See pamphlet published in December, 1930.

[6] See pamphlet published in April, 1931.

[7] Chapter 1 of Part 21, on "Condenser Leakage Tests," was published in pamphlet form in November, 1928.

### UNITS OF TIME

1 There are three time units in general use: sidereal time; true or apparent solar time; and mean solar time.

The period of time defined by two successive passages of any fixed star across the observer's meridian is known as a "sidereal day." This is the astronomical time unit.[8]

Besides rotating uniformly about its axis, the earth moves with varying velocity in an orbit (having the same direction of rotation) about the sun. The period of time defined by two successive passages of the sun across the observer's meridian is known as a "solar day." Irregularities of diurnal progress produce solar days of varying length.

The average length of a solar day in the course of a year is the "mean solar day," which is subdivided into 24 hours, each of which is subdivided into 60 minutes of 60 seconds each.[9]

2 *Standard Time.* Standard time is the time in a given belt of longitude referred to Greenwich, England. It is widely employed by agreement for civil time uses and measurements. It is based upon the value of mean solar time at a certain longitude within the belt. Standard time is made available universally by telegraph and radio signals sent out periodically. In the United States sidereal time is determined with extreme accuracy at the Naval Observatory in Washington from frequent observations upon a number of fixed stars. These observations are used to determine the errors of three Riefler Precision Clocks keeping sidereal time.

3 *Code Time (Time Used in A.S.M.E. Test Codes).* Code time is the same as standard time sent out by telegraph or radio. There are 60 seconds in 1 minute, 60 minutes in 1 hour, and 24 hours in 1 day. The 24 hours of each day are divided into two equal parts of 12 hours each, the hours being numbered successively from 1 to 12. From 12 o'clock midnight to 12 o'clock noon, time is designated as a.m. (ante meridiem); from 12 o'clock noon to 12 o'clock midnight, time is designated as p.m. (post meridiem). On shipboard (for naval acceptance tests) time is counted throughout the 24 hours successively beginning at midnight.[10] That is, 8 o'clock in the morning, on land, is also 8 o'clock on shipboard; but 3 o'clock in the afternoon, on land, is 15 o'clock on shipboard.

4 Mechanisms of uniform motion, when properly calibrated and adjusted, become suitable for "telling time." These mechanisms are of a variety of forms known as clocks, chronometers, and watches, etc. For Code purposes these will be called collectively "timekeepers." As used by astronomers, these are adjusted to the sidereal day; for civil measurements and Code measurements these are adjusted to the mean solar day.

### GENERAL REMARKS WITH RESPECT TO ACCURACY OF TIMEKEEPERS

5 The term "accuracy" of a timekeeper refers to its error and to its rate. The error is its deviation from the time standard and is determined by comparing it with a source of standard time. The rate is the amount it gains or loses per day (or sometimes per hour) compared with the time standard and is determined from a succession of observations covering several days.

[8] For further treatment see "Horology," by J. Eric Haswell.

[9] The mean solar day is longer than the sidereal day by 3 sidereal minutes and 56.55 seconds.

[10] Some foreign countries also use 24-hour time for civil time.

The rates which may be expected in practice are given in subsequent paragraphs under the discussions of the different types, and timekeepers used in Code measurements should be adjusted to rate within these values.

6 At Washington two time-distributing clocks indicating Eastern Standard Time are kept adjusted to the Riefler Precision Clocks. Each day at 11:55 a.m. Eastern Standard Time, time signals are sent out by radio and by telegraph as seconds clicks from one of the time-distributing clocks, with suitable omissions for half-minute and minute markers. Signals are also sent at 10 p.m. and 3 a.m. These time signals are remarkably accurate. Time is determined in Washington within a few thousandths of a second. The distributing clock is correct to within a few hundredths of a second. The observed signals are, no doubt, accurate to within a few tenths of a second. Bimonthly correction sheets may be obtained from the U. S. Naval Observatory giving corrections to 0.001 second.

7 *Use of Standard Time Signals.* Where a high-grade or regulator clock is available, daily comparisons should be made with the Standard Time Signals to determine its error and its rate. For most accurate work the comparison is made by a chronograph. Visual observation of the timekeeper compared with the time signals will give results accurate enough for most purposes (plus or minus 0.5 second). Subsequent comparisons of other timekeepers can then be made by comparison with the regulator clock. If a regulator clock is not available, then daily comparisons of the timekeepers to be used during Code tests should be made with the Standard Time Signals.

8 *Comparison of Timekeepers.* Timekeepers to be used in Code measurements should be compared at frequent intervals with a source of standard time to determine their error and the rate under conditions of use. The frequency of such comparisons should be such that the rate may be known to a precision commensurate with that of the measurements being made. The principal factors affecting accuracy are temperature, position, and isochronism, and the comparisons made should show the errors resulting from each of these factors. The temperature test may be made in a special test box at different temperatures, comparing the timekeeper with the standard at the same time each day for several days. The position test may be made by placing the timekeeper in various positions, and comparing with the standard at the same time each day for several days. The test for isochronism may be made by winding the timekeeper and allowing it to run down, comparing it with the standard every hour or two. The methods of making these tests on watches and the interpretation of the results are given in Circular No. 51, U. S. Bureau of Standards, entitled "Measurement of Time and Tests of Timepieces" to which reference should be made.

## TIME-TELLING MECHANISMS OR TIMEKEEPERS

9 There are many different types of timekeepers and time recording and transmitting devices. The following types are discussed in succeeding paragraphs.

(*a*) General-Purpose Clocks for indicating time to the nearest minute or, in some cases, to the nearest second. Used occasionally.

(*b*) Chronometers for indicating time to the nearest second. Used extensively on ships.

(*c*) High-Grade Clocks or Regulators for indicating time to the nearest second. Rarely used directly; available in well-equipped laboratories for standardizing watches and clocks, and as a source of seconds time intervals for standardization and measurement purposes.

(*d*) Precision Clocks are extremely accurate timekeepers which are used in astronomical observatories and watch factories. These are not used in Code measurements.

(*e*) Watches for indicating time to the nearest second. Used extensively.

(*f*) Stop Watches for measuring time intervals to the nearest fifth of a second. Used extensively.

(*g*) Timers for measuring time intervals to the nearest second, 0.1 second, or better. Convenient for many measurements.

(*h*) Chronographs for recording time intervals to within 0.02 second, or better. Many applications.

(*i*) Oscillographs for recording very short time intervals. The magnetic type will record an interval of the order of $10^{-4}$ seconds, and the cathode ray type $10^{-7}$ seconds. Used in special applications.

## GENERAL-PURPOSE CLOCKS

10 *Description.* A clock is a mechanism which may be suitably adjusted for "telling time" by means of a uniform (nearly always circular) motion of "pointers," around a graduated dial. Such a mechanism requires a driving force and a regulating mechanism. The driving force may be supplied by (*a*) a weight, (*b*) a coiled spring, or (*c*) electric energy. The regulating mechanism may be (*a*) a pendulum, (*b*) a balance wheel, or (*c*) an electromagnet or motor.

11 The weight-driven, pendulum-controlled clock is one of the most accurate types. Weights drive a wheel-train mechanism with uniform torque, as compared to the varying torque applied by a spring. They are therefore always used when exactness of time measurement is of more importance than compactness or portability. The weights drive the clock train through an escape wheel, the speed of which is controlled by oscillations of a pendulum. The period of the pendulum depends upon its physical dimensions and the frictional resistance of the surrounding air. By using proper materials, variations of physical dimensions due to variations of temperature are compensated for. Control of temperature and pressure in an enclosed clock mechanism provides a more nearly exact compensation. Variation of friction in the clock train affects its accuracy and the consequent errors can be reduced to a minimum only by careful workmanship. The fast and slow adjustment is made by raising and lowering the center of gravity of the pendulum, either by raising or lowering the pendulum bob or by subtracting or adding small weights. Clocks of this type should be mounted where they are free from vibration.

12 A spring-driven mechanism may be controlled by a pendulum or a balance wheel. Such a mechanism is subject to error due to the decreasing spring tension as the clock runs down. When the balance-wheel control is used, the mechanism is more portable and compact. The oscillations of the balance wheel depend upon its physical dimensions and the length of the control hair spring. Variations in the balance-wheel dimensions due to temperature variations introduce errors, although they may be largely compensated for. The accuracy of the balance wheel is also affected by variations of air pressure. Adjustment is made by an adjusting lever which lengthens or shortens the hair spring.

13 In electrically driven clocks, electric power is used to drive or to help drive the mechanism and has no part in the control. Such clocks are sometimes equipped with a driving motor which keeps the spring wound. In others, the electric power acting directly on the pendulum maintains its oscillations.

14 An electric clock, as distinguished from an "electrically driven clock," depends upon the impressed voltage for its motive power and control. Where the gear train is driven by a small synchronous motor, the clock is as accurate as the frequency of the alternating-current supply. Where it is driven by a direct-current motor, the accuracy depends on the voltage regulation.

In some clocks the motive power is controlled by the oscillations of a tuning fork or a piezo crystal.

15 *Accuracy.* General-purpose clocks, described in Par. 9, though not extensively used for Code measurements, are nevertheless adjustable to very uniform rates. The following rates are attainable:

| | |
|---|---|
| Weight-driven, pendulum-controlled (not including precision or regulator clocks) | 2 to 5 seconds per day |
| Spring-driven, pendulum-controlled | 2 to 5 seconds per day |
| Spring-driven, balance-wheel-controlled | |
| (*a*) Such as the common alarm clock | 2 to 10 seconds per day |
| (*b*) Such as used in curve-drawing instruments to drive the chart | 30 to 60 seconds per day |
| Electrically driven clocks | Rate uncertain |
| Electric clocks | |
| Synchronous-motor-driven | Rate depends upon constancy of frequency. Regulated independent systems may have a rate of 2 seconds per day or better; for other systems the rate is uncertain |
| D-c. motor-driven | Rate is quite uncertain and depends upon voltage regulation. |

As generally supplied, these clocks have hour and minute hands allowing readings to be made to the nearest minute; sometimes they are equipped with second hands and read to the nearest second.

16 *Use.* For Code measurements general-purpose clocks may be used occasionally for measuring relatively long intervals of time, such as several hours. For such use there is no special technique involved, the time being read in the usual manner from the position of the hands.

17 *Care.* Clocks should be mounted on a base which is free from vibration and where the temperature is reasonably constant. A pendulum clock should be placed on a level base so that the time interval between successive ticks is uniform. A firm support for a clock not only makes for safety but for better operation. Dust should be avoided.

18 Clocks should be wound regularly, not too tightly. It is well to know the number of half-turns necessary for winding so that the last two may be made carefully and slowly. A clock should be set forward, though it may be set backward, say, not more than two or three minutes.

19 Clocks should be cleaned and oiled by a qualified person at least every two years, preferably once a year. The mechanism will accumulate dirt, the oil will thicken and become gummy, and if the condition goes far enough, the clock will stop. A preliminary symptom of this condition is a varying loudness of ticking, or a changing rate (the clock may actually stop and start again from room-temperature change). Clocks should be cleaned before this condition exists.

## CHRONOMETERS

20 *Description.* A chronometer is a portable spring-driven clock controlled by a balance wheel. The helical balance spring and spring detent or "chronometer escapement" is mechanically superior to any other kind, requires no oiling, but is unsuitable to ordinary clocks for if stopped it has no tendency to start. It is particularly adapted for use on shipboard, though it may be used in testing on land. It should be moved about only with the greatest of care. As usually constructed, it is about the size of an ordinary alarm clock, being about four inches across. It is usually mounted in a square box on gimbals like a ship's compass, and so remains horizontal whatever the inclination of the ship.

21 *Accuracy.* A chronometer may be adjusted to a rate of the order of 0.2 to 0.4 second per day. The error may be kept within 10 seconds per month with only occasional adjustment.

22 *Use.* Chronometers may be read in the usual manner from the position of the hands or fitted with electrical contacts.

23 *Care.* In order to obtain the best results, it is essential that care and attention to all details be exercised. As far as possible a chronometer should be kept in one location. Hanging of the movement in gimbals keeps it level and improves its accuracy since it is designed to operate in this position. The location should be free from vibration, jars, or violent shocks. On shipboard, it should be placed so that the engine vibrations affect it as little as possible. Magnetic fields should be avoided, and the location should be clean and free from dust.

24 The rate of a chronometer is affected by variations of barometric pressure, of moisture content of the air, and of temperature. The last is by far the most important. It is usually not possible to control the entire surroundings of a chronometer, but if it is, then the pressure, moisture, and particularly the temperature, should be kept as constant as possible.

25 For transportation over short distances by hand, the movement should be rigidly clamped in its gimbals, for if left free to swing, its performance may be deranged by violent oscillations. For transportation by express, the chronometer should be allowed to run down, and should be dismounted and packed by a qualified person. It should be unpacked and put into operation by a qualified person.

26 All chronometers are wound by key. In the bottom of the brass case is a key hole covered by a dust cap held in place by a spring. In winding, the chronometer should be turned slowly and carefully in the gimbals until the winding hole is exposed. The dust cap is then pulled up and the key inserted. The necessary number of half-turns should be known, so that the last one may be made very slowly and carefully. Some instruments of recent design have a stem-winding and setting device in place of the key; and are often equipped with a winding indicator which gives a warning when winding is nearly completed. For best results winding should be done at the same hour each day, and exactly the same amount of main spring used. After winding, some advocate turning the chronometer slowly until the dial is down, and then returning it to its normal position, on the theory that this redistributes the oil on the pivots in the best manner possible.

27 Most chronometers are set by means of the key. They should be set no oftener than absolutely necessary, for the pressure of the key and the strain on the time train may change the rate of running. Setting the hands forward should be done slowly and steadily. It is usually said that a chronometer should not be set back. It seems a lot of trouble, however, to set a chronometer ahead nearly twelve hours when it is necessary to set it back only a few minutes. If it is set back, it should be given a quick turn, setting it back more than the desired amount and then set slowly forward to the time desired. A jeweler ordinarily takes the movement out of the case and then stops the balance wheel with a soft brush for the desired time interval. It is better for an inexperienced person not to try this, however. There is ordinarily no method provided for setting the seconds hand, except by stopping the chronometer. To push the seconds hand with a knife blade, for example, is "chronometer murder."

28 Opinion varies as to how often a chronometer should be cleaned and oiled; the interval recommended varies from two to seven years, although it depends largely on the care it has had.

# Engineering and Industrial Standardization

## American Standard Fire-Hose-Coupling Screw Thread Adopted by the State of California

TWO YEARS of intensive and intelligent effort on the part of the A.S.M.E. Local Section in San Francisco in cooperation with other groups has resulted in the passage of a law by the State of California making use of the National (American) Standard Fire-Hose-Coupling Screw Thread compulsory for all protected cities and towns within the state. Albert P. Hahn, member of the section, was a leader in this movement. In his final report he says that the major obstacle experienced was the apathetic attitude of the fire officials of the various municipalities, who granted the value of standardization, but who would not undertake concerted action of an effective nature.

At one meeting of fire chiefs after a talk on standardization, a resolution was passed instructing the presiding officer to appoint a committee to draft a bill for presentation to the legislature. The secretary, however, lost the minutes and the presiding officer was too busy in the following weeks to appoint a committee, although requested to do so several times.

The existence of the "Pacific Coast Standard" added further to the apathy of fire officials. This standard, generally in use on the Pacific Coast prior to the adoption of the National Standard by the State of Washington, consisted merely of an outside dimension over male threads and a pitch specification. Without a manufacturing or inspection tolerance, variations were unavoidable. A difference of $^1/_{64}$ in. on $2^1/_2$ in. nominal was found on the working blueprints of two leading Western manufacturers of hose couplings. Inasmuch as couplings are ordered for fire departments by hose manufacturers, it was often possible to find couplings from different manufacturers with different outside dimensions within the same department and even on the same piece of rolling equipment. For self-protection hose manufacturers demanded samples of couplings in use from the municipalities ordering hose, and ordered, in turn, couplings according to the sample. This led to a wide divergence in coupling dimensions, which was rather vividly illustrated at the Berkeley conflagration of September, 1923, where outside fire equipment sent to Berkeley's assistance was in many instances unable to use Berkeley hydrants. A similar condition occurred at the Mill Valley fire in the summer of 1929.

Individual examples of non-standard conditions were furnished by several fire chiefs. In one case a chief of a small department took a male coupling at random from service and attempted to mate it with other couplings in his department and found numerous misfits. Another chief in converting his department to National Standard found that a National Standard hydrant had been installed on a new $250,000 municipal pier and that it would have been impossible to connect his Pacific Coast equipment to that hydrant.

When the promotion of the National Standard was first undertaken in California it was hoped that the Board of Fire Underwriters of the Pacific would make the conversion. At the same time, after a survey of existing conditions, it was attempted to work up a receptive attitude among the fire chiefs. The Board however, represents only about two-thirds of the fire underwriting companies in the state and its advisory council could not assess its members for a measure that would redound equally to the benefit of non-contributing companies. It therefore became necessary to resort to legislative action to effect standardization. Inasmuch as the measure would affect fire chiefs and would require their political support, appeal was made to various chiefs' organizations in an attempt to have them draft and present their own bill to the legislature. After a year of delay a bill was finally drafted with the assistance of the National Board of Fire Underwriters and presented to the state legislature. Some opposition by reactionary fire chiefs was circumvented by the State Fire Marshal, who was of invaluable assistance throughout the program.

The bill was passed through committee and both houses without trouble, the committee members having been previously canvassed by letter and in person on the importance of standardization.

The bill as passed provides that all equipment purchased for fire-protective purposes shall be equipped with the standard threads for fire-hose couplings and hydrant fittings. Standardization of existing fire-protective equipment is to be arranged for and carried out within five years by and under the direction of the State Fire Marshal of California. He is authorized to make such changes as may be necessary to standardize all existing fire-protective equipment in the state immediately after the act becomes effective, and to employ the necessary assistants to superintend this work. He is to notify industrial establishments and property owners, having fire-protective equipment, which in his judgment may be necessary for fire-department use, of the changes necessary to bring their equipment up to the requirements of the standard and to render them such assistance as may be available in converting their equipment to standard requirements. The bill makes it unlawful for any person, firm, corporation, copartnership, or agent thereof to sell or offer for sale in the State of California any fire hose, hydrant, fire engine, or other equipment with threaded parts for fire-protective purposes, unless the same be fitted and equipped with the standard thread for fire-hose couplings and hydrant fittings designated as the National Standard.

## Test Code for Automatic Refrigerators

WORK on the preparation of a standard test code for automatic refrigerators is being undertaken by the subcommittee on tests of the sectional committee on specifications for refrigerators (B38) under the procedure of the American Standards Association. The subcommittee has recently been reorganized for this purpose following its completion of a draft of a standard test code for ice refrigerators.

The test for automatic refrigerators will cover the following five principal elements of performance:

Ambient temperature under standardized conditions
Internal temperatures
Power input (electricity, gas or other fuel, and water)
Proportion of time in operation
Number of cycles of operation in a unit of time.

Charles E. Roe, Electrical Testing Laboratories, New York, N. Y., is chairman of the sectional committee, and of the subcommittee which will prepare the first draft of the code.

The American Society of Refrigerating Engineers and the Bureau of Home Economics of the U. S. Department of Agriculture are joint sponsors for the project.

# Shaft Couplings

## Proposed A.S.M.E. Standard for Integrally Forged Flanges for Hydroelectric Units

FOR some years beginning as far back as 1925 there has been a growing demand for the standardization of the dimensions of integrally forged shaft couplings such as are used for the connections between generator and turbine in hydroelectric installations.

The need for this standardization was strongly emphasized again in the spring of 1928 and the A.S.M.E. was asked to form a committee to undertake the work. This suggestion was then referred to the A.S.M.E. Hydraulic Division Executive Committee for recommendations, and the American Standards Association was informed of this situation. In December, 1928, the Division appointed a Committee on Shaft Couplings which consisted of representatives of six manufacturers of hydraulic turbines and electric generators. The personnel of the committee is as follows: D. J. McCormick, S. Morgan Smith Co., *Chairman;* A. J. Brown, Whiting Corporation; R. A. McCarty, Westinghouse Electric and Manufacturing Co.; H. G. Reist, General Electric Co.; Franz Schmidt, Allis-Chalmers Manufacturing Co.; and R. E. B. Sharp, I. P. Morris, and De LaVergne, Inc.

After making a careful study of all available data and taking into account existing designs, the A.S.M.E. Hydraulic Division's Committee developed a series of couplings dimensions which it considers will economically meet the present requirements of industry. This proposed standard in preliminary form is reproduced here in full for review and comment. All criticisms or suggestions which are received will be placed before the Committee. They should be addressed to C. B. LePage, Assistant Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.

After formal approval and adoption by the A.S.M.E. Council this proposal will become a standard practice of the Society and will be submitted to the American Standards Association for approval and designation as an American Standard under the proprietory standards procedure.

## Shaft Couplings

### Introductory Notes

*Flange Dimensions.* In determining the proportions of the couplings included in this standard, the diameter of the flange

**Shaft Couplings**

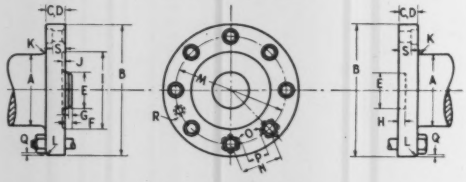


**Table 1 Coupling Dimensions**

| Diameter of Shaft | Diameter of Flange | Thickness of Flange: For Shaft Subject to Bending | Thickness of Flange: For Shaft Not Subject to Bending | Diameter of Rabbet[1] | Height of Rabbet[2] Above Face of Coupling | Depth of Rabbet Above Face of Coupling | Diameter of Relief[3] | Radius of Fillet | Radius of Corner |
|---|---|---|---|---|---|---|---|---|---|
| A | B | C | D | E | F | H | I | K | L |
| 3½ | 7½ | ⅞ | ⅞ | 2⅝ | 3/16 | ½ | ..... | 3/16 | 1/16 |
| 4 | 8½ | 1 | 1 | 2⅞ | 3/16 | ½ | ..... | 3/16 | 1/16 |
| 4½ | 9 | 1⅛ | 1⅛ | 2¾ | 3/16 | ½ | ..... | 3/16 | 1/16 |
| 5 | 10½ | 1¼ | 1¼ | 3 | 3/16 | ½ | ..... | 3/16 | 1/16 |
| 5½ | 10⅞ | 1⅜ | 1⅜ | 3¼ | 3/16 | ¼ | ..... | ¼ | 1/16 |
| 6 | 11½ | 1½ | 1½ | 3⅝ | 3/16 | ¼ | 6⅝ | ⅛ | 1/16 |
| 6½ | 12¾ | 1⅝ | 1⅝ | 3⅞ | 3/16 | ¼ | 7⅛ | ⅛ | 1/16 |
| 7 | 13½ | 1¾ | 1¾ | 4¼ | ⅛ | 5/16 | 7¾ | 3/16 | 1/32 |
| 8 | 14 | 1⅞ | 1¾ | 4½ | ⅛ | 5/16 | 8¼ | 3/16 | 1/32 |
| 8 | 15 | 2 | 1⅞ | 4¾ | ⅛ | 5/16 | 8¾ | ⅛ | 1/32 |
| 8½ | 15½ | 2⅛ | 1⅞ | 5⅛ | ⅛ | 5/16 | 9⅜ | ⅛ | 1/32 |
| 9 | 16¼ | 2¼ | 2 | 5⅜ | ⅛ | 5/16 | 9⅞ | 3/16 | 1/32 |
| 10 | 18 | 2½ | 2⅛ | 6 | ⅛ | 5/16 | 11 | 3/16 | 1/32 |
| 11 | 19¾ | 2¾ | 2½ | 6½ | ¼ | 5/16 | 12⅛ | 1 | ⅛ |
| 12 | 22 | 3 | 2½ | 7¼ | 5/16 | ⅜ | 13¼ | 1 | ⅛ |
| 13 | 23½ | 3⅛ | 2¾ | 7¾ | 5/16 | ⅜ | 14⅜ | 1⅛ | ⅛ |
| 14 | 25 | 3½ | 3 | 8½ | 5/16 | ⅜ | 15⅝ | 1¼ | ⅛ |
| 15 | 27 | 3¾ | 3⅛ | 9 | 5/16 | ⅜ | 16½ | 1⅜ | ⅛ |
| 16 | 29 | 4 | 3½ | 9½ | 5/16 | ⅜ | 17⅝ | 1½ | 3/16 |
| 17 | 30 | 4⅛ | 3½ | 10¼ | 5/16 | ⅜ | 18¾ | 1½ | 3/16 |
| 18 | 32½ | 4½ | 3¾ | 10¾ | 5/16 | ⅜ | 19⅞ | 1¾ | 3/16 |
| 19 | 34 | 4¾ | 4 | 11½ | 5/16 | ⅜ | 20⅞ | 1⅞ | 3/16 |
| 20 | 35½ | 5 | 4 | 12 | ⅜ | 7/16 | 22 | 1¾ | ¼ |
| 21 | 37¼ | 5½ | 4¼ | 12½ | ⅜ | 7/16 | 23½ | 2 | ¼ |
| 22 | 39 | 5½ | 4½ | 13¼ | ⅜ | 7/16 | 24¼ | 2 | ¼ |
| 23 | 40 | 5¾ | 4¾ | 13¾ | ⅜ | 7/16 | 25⅜ | 2 | ¼ |
| 24 | 42 | 6 | 4¾ | 14½ | ⅜ | 7/16 | 26⅜ | 2 | ¼ |
| 25 | 43½ | 6½ | 5 | 15 | ⅜ | 7/16 | 27½ | 2½ | ¼ |
| 26 | 45½ | 6½ | 5¼ | 15½ | 7/16 | ½ | 28¾ | 2½ | ¼ |
| 27 | 47 | 6¾ | 5½ | 16¼ | 7/16 | ½ | 29¾ | 2½ | ¼ |
| 28 | 24½ | 7 | 5¾ | 16¾ | 7/16 | ½ | 30⅞ | 3 | ½ |
| 29 | 50½ | 7½ | 5¾ | 17½ | 7/16 | ½ | 31⅞ | 3 | ½ |
| 30 | 51¾ | 7½ | 6 | 18 | 7/16 | ½ | 33 | 3 | ½ |
| 31 | 53½ | 7¾ | 6½ | 18½ | ½ | 9/16 | 34 | 3 | ½ |
| 32 | 55 | 8 | 6½ | 19¼ | ½ | 9/16 | 35¼ | 3 | ½ |
| 33 | 56½ | 8¼ | 6¾ | 19¾ | ½ | 9/16 | 36¼ | 3½ | ½ |
| 34 | 58¼ | 8½ | 7 | 20¼ | ½ | 9/16 | 37⅜ | 3½ | ½ |
| 35 | 60 | 8¾ | 7 | 21 | ½ | 9/16 | 38½ | 3½ | ½ |
| 36 | 61¾ | 9 | 7½ | 21½ | ½ | 9/16 | 39⅝ | 3½ | ½ |
| 37 | 63½ | 9¼ | 7½ | 22¼ | ½ | 9/16 | 40¾ | 3½ | ½ |
| 38 | 64¾ | 9½ | 7¾ | 23 | ½ | 9/16 | 41¾ | 3½ | ½ |
| 39 | 66½ | 9¾ | 7¾ | 23½ | ½ | 9/16 | 43 | 3½ | ½ |
| 40 | 68 | 10 | 8 | 24 | ½ | 9/16 | 44 | 3½ | ½ |

All dimensions given in inches.

[1] Note. The fitting allowance on dimension "E" for the male half-coupling shall be −0.001 inch for shafts up to and including 12-inch diameter and −0.002 inch for shafts larger than 12 inch.

[2] Note: The entrance edge of the rabbet for all shaft sizes shall have a 1/16-inch chamfer "G."

[3] Note: This relief shall be provided on the male half-coupling and shall have a depth "J" of 1/16-inch for all shaft sizes.

**Shaft Couplings**

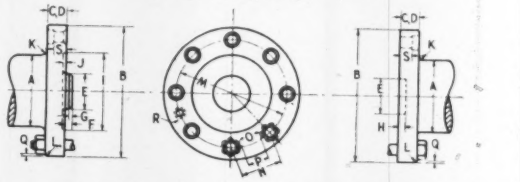


**Table 2 Drilling Layout and Bolt Dimensions**

| Diameter of Shaft | Diameter of Coupling Bolt Circle | Center Distance of Coupling Bolts | Coupling Bolts[1,2] O: Number of Bolts | Coupling Bolts[1,2] O: Body Diameter | Size of Nuts | Minimum Distance Between Nuts | Clearance for Nut Guard | Jack Bolts[3] R: Number of Bolts | Jack Bolts[3] R: Size of Bolts |
|---|---|---|---|---|---|---|---|---|---|
| A | M | N | | | | P | Q | | |
| 3½ | 5⅝ | 2 81 | 6 | ⅞ | ⅞ | 1 16 | 107 | | |
| 4 | 6¼ | 3 12 | 6 | ⅞ | ⅞ | 1 47 | 107 | | |
| 4½ | 6¾ | 3 43 | 6 | 1 | 1 | 1 56 | 124 | | |
| 5 | 7¾ | 3 87 | 6 | 1½ | 1½ | 1 56 | 095 | | |
| 5½ | 8¾ | 4 18 | 6 | 1¼ | 1¼ | 1 87 | 095 | | |
| 6 | 9 | 3 44 | 8 | 1½ | 1½ | 1 13 | 095 | | |
| 6½ | 9¾ | 4 87 | 6 | 1½ | 1½ | 2 13 | 128 | | |
| 7 | 10½ | 4 02 | 8 | 1½ | 1½ | 1 28 | 129 | 2 | ⅜ |
| 7½ | 11 | 4 21 | 8 | 1½ | 1½ | 1 50 | 13 | 2 | ⅜ |
| 8 | 12 | 4 58 | 8 | 1¾ | 1½ | 1 84 | 13 | 2 | ⅜ |
| 8½ | 12½ | 4 78 | 8 | 1¾ | 1½ | 2 04 | 13 | 2 | ⅜ |
| 9 | 13¼ | 4 10 | 10 | 1¾ | 1½ | 1 36 | 13 | 2 | ⅜ |
| 10 | 14½ | 4 47 | 10 | 2 | 1¾ | 1 29 | 16 | 2 | ⅜ |
| 11 | 16¼ | 5 02 | 10 | 2 | 1¾ | 1 84 | 162 | 2 | ⅜ |
| 12 | 18 | 5 56 | 10 | 2¼ | 2 | 1 95 | 19 | 2 | ⅜ |
| 13 | 19½ | 5 05 | 12 | 2¼ | 2 | 1 42 | 19 | 2 | 1 |
| 14 | 20½ | 5 32 | 12 | 2½ | 2½ | 1 29 | 23 | 2 | 1 |
| 15 | 22½ | 5 83 | 12 | 2½ | 2½ | 1 78 | 23 | 2 | 1 |
| 16 | 24 | 6 21 | 12 | 2¾ | 2½ | 1 71 | 26 | 2 | 1 |
| 17 | 25 | 6 47 | 12 | 2¾ | 2½ | 1 49 | 26 | 2 | 1 |
| 18 | 27 | 6 99 | 12 | 3 | 2¾ | 2 08 | 26 | 2 | 1 |
| 19 | 28½ | 6 33 | 14 | 3 | 2¾ | 1 43 | 29 | 2 | 1 |
| 20 | 29½ | 6 61 | 14 | 3 | 2¾ | 1 7 | 30 | 2 | 1 |
| 21 | 31½ | 6 96 | 14 | 3¼ | 3 | 1 62 | 33 | 2 | 1 |
| 22 | 32½ | 7 23 | 14 | 3½ | 3¼ | 1 46 | 36 | 2 | 1 |
| 23 | 33½ | 7 45 | 14 | 3½ | 3¼ | 1 68 | 36 | 2 | 1 |
| 24 | 35 | 7 78 | 14 | 3¾ | 3½ | 1 57 | 40 | 2 | 1 |
| 25 | 36½ | 8 10 | 14 | 3¾ | 3½ | 1 80 | 40 | 2 | 1¼ |
| 26 | 38 | 8 45 | 14 | 4 | 3¾ | 1 81 | 43 | 2 | 1¼ |
| 27 | 39½ | 7 70 | 16 | 4 | 3¾ | 1 06 | 43 | 2 | 1¼ |
| 28 | 41 | 8 00 | 16 | 4 | 3¾ | 1 36 | 43 | 2 | 1½ |
| 29 | 42½ | 8 29 | 16 | 4¼ | 4 | 1 22 | 46 | 2 | 1¼ |
| 30 | 43½ | 8 48 | 16 | 4¼ | 4 | 1 41 | 59 | 2 | 1½ |
| 31 | 44½ | 8 73 | 16 | 4½ | 4¼ | 1 22 | 62 | 2 | 1½ |
| 32 | 46¼ | 9 02 | 16 | 4½ | 4¼ | 1 51 | 62 | 2 | 1¼ |
| 33 | 47⅜ | 8 32 | 18 | 4½ | 4¼ | 0 81 | 62 | 2 | 1½ |
| 34 | 49½ | 8 56 | 18 | 4½ | 4¼ | 1 05 | 62 | 2 | 1¼ |
| 35 | 50¾ | 8 81 | 18 | 4¾ | 4½ | 0 87 | 65 | 2 | 1¼ |
| 36 | 52½ | 9 11 | 18 | 4¾ | 4½ | 1 17 | 65 | 2 | 1¼ |
| 37 | 53¾ | 9 33 | 18 | 5 | 4¾ | 0 96 | 69 | 2 | 1¼ |
| 38 | 55 | 9 55 | 18 | 5 | 4¾ | 1 18 | 69 | 2 | 1¼ |
| 39 | 56½ | 9 77 | 18 | 5½ | 5 | 0 96 | 72 | 2 | 1½ |
| 40 | 57¾ | 10 03 | 18 | 5¼ | 5 | 1 22 | 72 | 2 | 1½ |

All dimensions given in inches.

[1] Note: Allowance for reaming holes shall be 1/16 inch on diameter for bolts up to and including 1 1/4 inch body diameter and 3/32 inch for bolts larger than 1 1/4 inch.

[2] Note: Thread—For sizes under 1-inch use American Standard, Fine Thread Series.
For sizes 1-inch to 2-inch inclusive use 8 threads per inch.
For sizes over 2-inch up to and including 5-inch use 6 threads per inch.

[3] Note: Jack bolts shall be provided for horizontal shafts only.

in each case has been kept as small as possible without reducing the strength of the coupling below that of the shaft in either torsion or bending.

Two values of flange thickness are provided, the one dimension C, Table 1, for shafts which will be subject to bending and the other dimension D, for those which will not. If, however, in the case of the latter class of installation the hydraulic thrust is unusually great, some value of flange thickness between C and D should be used, and coupling bolts of special steel may be found necessary.

The following formulas apply to the standard coupling design:

Thickness of Flange (C) = 0.25 × Diameter of Shaft (A)

Thickness of Flange (D) = 0.2 × Diameter of Shaft (A)

Diameter of Rabbet (E) = 0.6 × Diameter of Shaft (A)

Diameter of Relief (I) = 1.1 × Diameter of Shaft (A)

For matching shafts of different diameters, either the dimensions of the larger coupling shall be used for both halves or the larger shaft shall be necked down near the coupling to the diameter of the smaller shaft and the dimensions of the smaller coupling shall be adopted for both.

For all vertical shaft installations the lower shaft shall be provided with the male half-coupling.

*Drilling and Reaming for Bolts.* The bolt holes shall be drilled smaller than the body diameter of the bolt and reamed to size with both flanges clamped together, and if the couplings will not be subject to reversing service the holes may be counterbored from the back of the flange. The depth of this counterbore shall not be such as to reduce the length of the reamed portion below 0.8 times the body diameter of the bolt, and the allowance for counterboring shall not be less than that specified for reaming as covered by Note 1, Table 2.

If a relief on the face of the coupling around the bolt holes is desired, it shall be provided on the male half-coupling and shall consist of a slight countersink.

*Bolts and Nuts.* The nuts shall be made to the American Standard dimensions and of the sizes shown in Table 2.

The body diameters of the bolts, also shown in Table 2, are based upon the assumption that the stress in the bolts may be safely as much as 20 per cent greater than the stress in the shaft. The diameter of the threaded portion of the bolts shall be determined by the size of the nuts.

The bolt heads shall be made to the American Standard dimensions and may be of the same size as the nuts or of the size corresponding to the body diameter of the bolts. In the latter case one flat shall be placed parallel to the periphery of the flange.

The bolts shall be straight (not tapered) and they shall be fitted to the holes, care being exercised to obtain a snug fit.

The length of the bolts shall be such that they will project slightly beyond the nut. The diameter of this projecting portion, which is to be used for driving when the bolts are removed, shall be smaller than the root diameter of the thread.

*Nut Guards.* In order to permit the installation of nut guards of the same outside diameter as the flange (dimension "B") a clearance, "Q," has been provided between the edge of the flange and the nuts, on the larger couplings. For the smaller couplings, however, it is assumed that the nut guards will overlap the flanges.

*Jigs and Templets.* If drilling jigs or templets are used they shall be centered on the rabbet.

*Sizes.* The shaft diameters covered by the following tables range from $3\frac{1}{2}$ inches to 40 inches. Most shafts requiring integrally forged couplings are of special design rather than a stock product and the greatest possible selection of sizes is required. For this reason, instead of following a series of preferred numbers, these standard shaft diameters increase by half-inch intervals up to 9 inches and by one-inch intervals from 9 to 40 inches.

# Correspondence

## Present Position of the Automatic Diesel-Electric Plant

TO THE EDITOR:

Mr. Kates' paper[1] is very interesting, and there is no doubt but that the automatic Diesel-electric plant he describes can be considered as a suitable source of power for an office building. The writer doubts very much, however, whether it will be widely adopted for that purpose unless there is a change in present conditions.

Owners of buildings today try to keep the amount of mechanical equipment to a minimum for several reasons. It is usually desired that the investment cost be kept as low as possible to facilitate financing. Basement space is frequently quite valuable, and the loss of revenue therefrom is an important factor to consider in determining the economic value of an isolated power plant for such buildings.

Reliability of service is of great importance to the operator of a large office building, and he would probably prefer to have his own force handle the operation and maintenance of the plant instead of depending upon an outside agency as suggested by Mr. Kates. This would involve a specialized group of employees and introduce labor problems that the managers of a building would prefer to avoid.

Additional information as to the actual cost of operation and maintenance and the reliability of the plant in the Hotel Chelsea would be of interest.

ALBERT H. MORGAN.[2]

TO THE EDITOR:

The great interest that building owners have taken in automatic Diesel-electric plants ever since information on the Hotel Chelsea installation was released indicates that in many cases the usual arguments against private power plants do not prevail. The value of the basement space occupied by an automatic plant of the type described is small, as the plant is quite compact both as to floor area and headroom. The 150-kw. installation in the Hotel Chelsea is contained in a basement room 22 ft. square with 8 ft. 7 in. headroom.

As for financing, several methods are available for installing an automatic Diesel power plant without requiring the building owner to make a large cash investment. The plant is easily able to pay for itself out of savings over corresponding costs for public service, and is being sold on this basis. Furthermore, due to the ease with which the plant can be placed in a finished building, it can be kept free of the building mortgage.

Continuity of service is so well safeguarded that there is no need

[1] "The Present Position of the Automatic Diesel-Electric Plant," by E. J. Kates. Presented at the A.S.M.E. National Oil and Gas Power Meeting, Madison, Wis., June 23–26, 1931, and published, slightly abridged, in MECHANICAL ENGINEERING, July, 1931, pp. 525–528.

[2] General Building Supervisor, Western Union Telegraph Co., New York, N. Y. Assoc-Mem. A.S.M.E.

whatever to put the supervision and maintenance of the plant in charge of the building's own force, instead of traveling experts. Not only are the engine supply services thoroughly safeguarded, but in case of trouble with any generating unit it is immediately shut down and disconnected, and the spare unit is put in service in a few seconds. Meanwhile full power supply is maintained by the running engines, supplemented by the storage battery. In fact, the battery alone can carry the entire load for a considerable period. The expected reliability of service has been demonstrated in the Hotel Chelsea, where the automatic plant has supplied the entire load without any interruption from January, 1931, to date (September).

Because of the reduced time needed for supervision in an automatic plant, the company selling this equipment can afford to employ a highly skilled force in the larger cities to inspect and maintain all plants at low unit cost.

As to actual costs, the fuel and lubrication oil in the Hotel Chelsea plant averages 6.3 mills per kilowatt-hour, of net output, fuel oil costing 6 cents per gallon delivered. The time required for adequate supervision and maintenance has been found to be 100 man-hours per month (for 24-hour service). The initial cost of an automatic plant, including storage battery, is less than $50 per kilowatt over the cost of a plant containing generating units of the same size manually operated.

EDGAR J. KATES.[3]

## How Coal Market Values Are Related to Steam-Plant Design and Operation

TO THE EDITOR:

Mr. Gould's paper on this subject in the July issue of MECHANICAL ENGINEERING is a particularly valuable contribution in that it reaches down to fundamentals.

The difference between utilization efficiency of heat units and that of overall plant economy is important and will bear emphasizing. The former is merely a thermal-engineering ratio indicating the proportion of useful net to total consumed; while the latter takes in financial accounting as well, and really represents what might be called the efficiency of the dollar.

True or ultimate economy depends of course not only upon expenditures for fuel alone, but also upon expenditures for the entire power-plant equipment designed for the utilization of fuel.

Dollar utility may be said to be the essence of superior engineering. And a given plant may sometimes operate at greater "dollar economy" when using a comparatively low-grade, inexpensive fuel than when using a more expensive fuel producing higher thermal efficiency.

And again, the same coal used in two separate plants of different design may result in better "dollar economy" in the plant operating at lower thermal efficiency, because of the use of less elaborate and less costly refinements in equipment.

These features are pretty well understood and need emphasis rather than elaboration.

It has long been recognized that a dollar invested wastefully in equipment, besides earning no dividends, is lost and buried forever. But unfortunately sometimes we are apt to forget, for the moment, that the self-same dollar often has the habit of taking down with it other dollars, involving also wasteful maintenance expense as well as burdensome fixed charges in the form of interest, depreciation, taxes, and insurance.

It is probable that today, as never before, we need to scrutinize capital expenditures as well as running expense to make sure as to their justification. And this paper clearly indicates the importance of starting with fundamentals, that is, with the coal pile, in accomplishing this end.

WENDELL S. BROWN.[4]

TO THE EDITOR:

It is undoubtedly true, as Mr. Gould suggests, that until quite recently coal was purchased on the basis of its physical appearance rather than its energy value. Price, of course, has always been a dominant factor in the coal market, but the actual cost of energy, as distinct from the cost per ton, played a relatively minor part. Nor was this basis of selection confined to the small consumer. It applied equally to consumers whose fuel costs formed a major item of the total operating expense. But within the past twenty years important changes have taken place. The consumer of today has been educated in the principles of combustion and is no longer guided by unreasoning preferences, but has a very definite knowledge of the type of coal best suited to his particular requirements. Although the rapid advance in fuel efficiency that has been witnessed in recent years is not likely to continue indefinitely, there still remains room for great improvement, especially in the small steam plant.

The results of this "consumer education" are well known, and from the point of view of the coal industry it has been a development fully as significant as the rapid rise in the use of competitive sources of energy. The most striking evidence of its effects is afforded by the record of the electric public utilities, whose consumption of coal per kilowatt-hour of electricity generated has declined from 6.4 lb. in 1902 to 1.62 lb. in 1930. Similar, although somewhat less spectacular, economies have been effected by other important consumers. Between 1909 and 1929 the steam railroads show a saving of 47 per cent in their unit consumption of energy, the petroleum-refining industry a saving of 36 per cent, the iron and steel industry 25 per cent, and the cement plants and the miscellaneous manufacturing industries 21 per cent. For all branches of industry and rail transport it is calculated that during the same 20-year period there has been a saving of 33 per cent in the unit consumption of energy. Thus the aggregate consumption of fuel and hydroelectricity in industries and rail transportation in 1929 was only 67 per cent of what it would have been had the thermal efficiency remained at the same level as in 1909.

Part of the credit for this great record of achievement belongs to the coal industry itself. During the past few years one of the outstanding technological developments in the bituminous-coal industry has been the progress in the field of preparation. To be sure, this sudden interest of producers in preparation has been largely inspired by the tightening of competition and the increasing discrimination of consumers, but whatever the incentive, the net result is that a more carefully prepared and cleaner coal is being marketed today than ever before.

What the bituminous industry is now experiencing was witnessed a quarter of a century ago in the anthracite region of Pennsylvania, and still earlier in the principal European coal-producing countries. It is estimated that in Belgium over 85 per cent, in France nearly half, and in Great Britain over a quarter of the marketable coal at present produced is either washed or subjected to pneumatic cleaning; while in Germany, as far back as 1913, nearly 75 per cent of the "Steinkohle" output was washed. In the United States, on the other hand, until quite recently never more than 5 per cent of the bituminous coal produced was mechanically cleaned. In 1929 a total of 37,143,000 tons, or 7 per cent of the bituminous coal produced, was cleaned by wet-washing or pneumatic methods, and this figure does not include the enormous tonnage of lump and egg coal hand-cleaned on picking tables.

There is an evident explanation why the bituminous producers

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[4] Engineer, F. P. Sheldon & Sons, Providence, R. I. Mem. A.S.M.E.

of this country until lately have lagged behind in adopting improved methods of preparation. In the first place, large reserves of high-grade coal requiring little or no treatment have been readily accessible. Moreover, these reserves made possible a degree of selective mining which permitted the production of only the cleanest coal. Conditions, however, are changing. With the pressure from large tonnages turned out by machines incapable of selective mining, with the increased sensitivity of consumers to quality, and with the need for mining seams containing a larger proportion of impurities, the bituminous operators of the United States are turning to mechanical cleaning for the solution of their problems just as the anthracite and Continental producers were forced to do a number of years before.

H. O. ROGERS.[5]

TO THE EDITOR:

Mr. Gould's points on power-plant limitations are well taken, and he expresses clearly and unmistakably, with sufficient quantitative information to drive it home, what many operating men have felt for a long time when called on to operate plants containing certain types of equipment. There are still enough legitimate differences of opinion as to just where certain types of stokers quit with certain coals, and it would be probably unfair even for one entirely unconnected with either the stoker or the coal business to tabulate a rating of the adaptability of different stokers to different coals, and would certainly stir up more argument than the writer now feels like undertaking. But all experienced operators know that each type of stoker, straight overfeed, V-type overfeed, single or multiple-retort overfeed, etc., has one general type of coking characteristic of the coal to which it is best adapted, and in a more general way a best efficiency at some particular combustion rate in pounds per square foot per hour, and the farther practice departs from these the harder it is to secure the highest efficiency. Some stoker types have a much wider range both of coking characteristics and burning rate, and, where other conditions permit, these are the best choice.

It is on the question of coking characteristics that the writer differs from Mr. Gould's use of the expression "volatile matter." The two have been very much confused in the past since they more or less vary together, but the smoke-making characteristics of a coal, which is the chief objection to high-volatile percentage, may vary almost as much from the composition of the volatile matter and rate of coking as from its percentage. And from the standpoint of fuel-bed characteristics and efficiency of combustion, the coking characteristics are the more important requirement. At high ratings, high ash and low fusing temperature, causing excessive clinker formation, handicap coals having these characteristics on any form of stoker, and penalize them even with the best equipment as it is impossible to maintain as uniform fuel-bed conditions to obtain the best results in percentage of excess air, and low ashpit losses, even with clinker grinders, are increased so that coals deficient in these respects should not be rated equal with lower-ash and higher-fusing-temperature coals in a B.t.u.-per-dollar comparison.

Two items which are not mentioned specifically in the paper have too large an influence in the purchase of coal. The first of these is ignorance—too much coal tonnage is placed by the plant manager on the same basis as insurance; the coal dealer is a friend, and he can furnish something similar to what is needed, though sometimes the likeness is remote. This goes further in that when samples are taken for analysis the necessary care is not exercised to make them representative—it is a real job to do this without special sampling machinery—and the buyer usually fools himself into believing he is getting a better coal than is being delivered. Much of this is unnecessary as the Bureau of Mines and other agencies have standardized methods of sampling and published sufficient analyses of coal from all sections of the country that the prospective purchaser can usually find an analysis of the coal offered by which to check his own sample and the seller's claims for it.

Last, and by far the most important in fixing the cost and relative economy of coals in Southern New England, is the transportation cost. Where the price at the mines represents only 20 to 30 per cent of the delivered cost of the coal, any change the operator can make in mining cost or quality is overshadowed by other items over which he has little or no control. By virtue of a lower freight rate for a considerably longer haul to tidewater, low vessel rates based on more modern loading and discharging equipment and efficient colliers, and very low auto-trucking rates (probably uneconomically low), Southern West Virginia coals have become unbeatable competitors within trucking range of Atlantic ports equipped with suitable discharging equipment, and even a considerable distance inland on railroad lines. Such a situation introduces an almost incalculable element, as unfortunately at present freight rates are too much influenced by other than purely economic considerations.

The use of anthracite steam sizes is largely limited to plants on the same railroad as the mines, except for a few unfortunately equipped plants which must use an extremely low-volatile coal to comply with the smoke laws, and which pay accordingly in transportation costs.

The writer believes that more discussion along the lines of Mr. Gould's paper and accumulation of information available to designers and operators on the adaptability of coals and coal-burning apparatus to each other, will go far to improve the situation he describes.

H. D. FISHER.[6]

TO THE EDITOR:

The question which Mr. Fisher raises regarding coking qualities of coal introduces one of those coal characteristics which have to be given more consideration in some plants than in others. This is, however, one of the characteristics of coal which, up to the present time, is not capable of exact definition and measurement. It was the purpose of this paper to confine the study of the relation of coal characteristics to market values to those characteristics which are capable of exact definition and which consequently would lend themselves to statistical demonstration.

Mr. Rogers very properly points out that there has been a distinct change in the work done per pound of coal during the past twenty years, particularly in the case of the electric utilities and the railroads. These gains, however, along with those noted in the petroleum industries, iron and steel and the cement plants, while important from the standpoint of total consumption, may be considered as special cases somewhat outside the intended scope of this discussion. Steam generation from coal in industrial plants, particularly in the eastern section of the country, in that large group of plants which might be classed as miscellaneous industries, will have a long way to go before what might be classed as the best practice known becomes really generally applied.

Our current engineering literature, for obvious reasons, presents only the bright side of the picture, and it is only by actual contact with the plants themselves that one realizes how far short general practice falls of the best obtainable performance which is more often the subject of published data.

G. B. GOULD.[7]

[5] Statistics Section, Coal Division, Department of Commerce, Bureau of Mines, Washington, D. C.

[6] Plant Engineer, The New Haven Pulp and Board Co., New Haven, Conn. Mem. A.S.M.E.

[7] President, Fuel Engineering Company of New York.

# MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of

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## A Good Job

IN THE section devoted to Standardization in this issue will be found the summary of a report on the activities of the A.S.M.E. Local Section in San Francisco that resulted in a California state law requiring the adoption of the American Standard fire-hose-coupling screw threads. In spite of the rather obvious advantages of this standardization, it took some hard work to pass the law adopting it. The engineers who put the thing across have done a good job. Their success should stimulate others to exercise their cooperative efforts in securing similar results elsewhere. By such acts engineers can make use of their special knowledge for the benefit of the communities in which they live, and in so doing bring credit and distinction to their profession.

## Engineering and Metaphysics

TO AN old-style engineer metaphysics was something that he should leave severely alone. As its name implies, metaphysics is devoted to the discussion of things beyond direct human ken. In plain words, it is an attempt to imagine something we know nothing about and have no basis for learning. Contrasted with metaphysical doctrines only a short time ago were the so-called exact sciences on which the engineer bases his conclusions and designs.

It is a remarkable illustration of change in views that a great scientist like R. Plank tells a body of level-headed men, such as the German Society of Engineers, that physics has already stepped over into the bounds of metaphysics and that the two sciences are rapidly converging to a point where close cooperation may be possible between them. He points out that this is due in part to the fact that metaphysics is gradually adopting the methods of research and reasoning of the exact sciences. Apparently we are gradually drifting into a state of affairs where an engineer will have to be familiar with the theories of philosophers, just as now he must know the latest developments in the composition of matter or the behavior of films. Still farther in the distance looms the single science of which Plank speaks, and which in one magnificent sweep will include and coordinate all human knowledge.

## The Liquid Engine—A New Type of Prime Mover

THE Malone liquid engine described in the Survey of Engineering Progress in the present issue of MECHANICAL ENGINEERING is unquestionably a most interesting achievement. The principle on which it operates is extremely simple and involves the same process of expansion and contraction of a fluid due to heating and cooling that is dealt with in the steam or gas engine. The only difference is that a liquid fluid is used instead of a gas or vapor. That the expansion of a liquid fluid can produce a tremendous effect is well known. In the past, however, it was generally assumed that heating and cooling would be too slow in operating a prime mover of reasonable volume and weight. The ingenious use in a regenerative process of liquid films instead of great solid masses of liquid made possible the Malone engine.

According to the author's statements the engine, that has been seen in operation by a number of prominent engineers, is of about 50 hp., weighs some 300 lb. per hp., runs at speeds of from 40 to 250 r.p.m., and has operated 12 hours a day for nearly a year. It is too early to speak of comparative efficiencies, but if this type of engine can be made to operate at rates at all comparable with those of other prime movers, it will probably find a place for itself among the various means of power generation.

## Engineering-Economics Conferences

UNDER the joint auspices of Stevens Institute of Technology and Columbia University there was held at the Stevens Engineering Camp, Johnsonburg, N. J., August 29 to September 7, a series of conferences on economics for engineers. Mornings were devoted to lectures and problem work in corporation finance, afternoons were free for recreation, and the evenings were devoted to the conferences.

The conspicuous success that attended these conferences and thereby justified them was due in large measure to the enthusiastic leadership of Dr. Harvey N. Davis, president of the Stevens Institute of Technology, in providing an excellent program and in steering the discussion into interesting and profitable channels. Without such leadership discussion would have lacked the spontaneity that made it so stimulating and the messages brought to the conferences by the eminent persons who addressed them would have proved less stimulating. For it was in the give and take of debate between the speakers and their audience that certain points were hammered home and others laid open to question.

The causes and cures of business depressions, which were the principal topics discussed at the Camp, involve variables greater in number and of a nature different from those customarily encountered in engineering problems. Facts, theories, and opinions become almost hopelessly confused. The "one best way" is not apparent. Rationally conceived solutions run afoul of persistent traits in human nature and in social and economic experience, to say nothing of legal obstacles. So it must not be expected that a precise formula was established, nor that each

individual came away with a definitely purposeful program which he could put into immediate practice. Every one had his pet theory bolstered up or knocked into a cocked hat. Every one was impressed with the difficulties attending an adequate solution of the problem. Every one admitted the desirability of some sort of control of economic processes, but recognized that "the common problem—yours, mine, every one's—is not to fancy what were fair in life provided it could be, but, finding first what may be, then to make it fair up to our means."

Statisticians, economists, and engineers were the speakers at the conferences, and the audiences were made up largely of younger engineers interested in economic and social problems. In view of the fact that bankers came in for a considerable amount of criticism, it is unfortunate that the banking profession was not adequately represented, either to refute the criticism or to point out what special conditions limit effective action by this group. The loss in world production due to the war was frequently alluded to, and international peace and understanding were hailed as factors that would assist economic stability. Economic councils and planning boards were proposed by several speakers and the anti-trust laws were criticized. Especial interest attached to the distressing economic plight of the machinery industry and the need for a machinery equipment policy.

Owing to the wasteful processes of nature it is improbable that economic depressions will cease because of these conferences, but even a meager fruitage from the seeds sowed in the minds of those attending will justify the efforts expended. Next year's conferences, promised by Dr. Davis, will draw a greater number of participants and further establish the Stevens-Columbia Economic Camp as a significant adventure in adult education and an important contribution of engineering to economics.

## Noise of Aircraft

ATTENTION is called to the abstract, printed elsewhere in this issue, of the paper on noise presented recently by A. H. Davis of the Physics Department, National Physical Laboratory, England. Our only regret is that limitation of space did not permit a more extensive abstract of the original paper and discussion.

The two points to which special attention is called are (1) that the loss of power represented by noise is comparatively negligible in so far as the airplane itself is concerned, and (2) that there are a large number of noises, all of which apparently can be segregated, measured, and eventually reduced or eliminated. As aviation develops, the matter of noise will undoubtedly gain in importance and may become cardinal. The problem should be considered from two different points of view: (1) that of the passengers within the cabin, and (2) that of other persons outside the plane.

From the paper by Dr. Davis and the discussion, it would appear that the problem of providing a noiseless or reasonably noiseless airplane cabin has either been solved or is on the way toward an early solution. The comfort of the passenger may be considered as being assured. Unfortunately, the same cannot be said about the noises affecting those outside the plane. That these noises may become a serious nuisance has already been shown by the attitude of residents near air fields. In several instances complaints have been made to local authorities. Authorities are loath to interfere with the growth of an industry which may have far-reaching effects on human life and which is decidedly only in its infancy today. As the application of aircraft extends, however, effective silencing will become necessary, either through the natural development of the art or the compulsion of the courts.

From Dr. Davis' paper it is evident that the silencing of the engine is well under way and may be accomplished at an early date, as the origin of noises and the methods of their propagation are fairly clear. Propeller noise is beginning to be understood, and understanding of a problem is the first step in its solution. As the major sources of disturbances are eliminated, the minor noises will probably become noticeable. It may therefore take some time before a reasonably noiseless airplane is produced, but there is every reason to believe that this will be accomplished before very long.

## Unemployment Legislation

UNEMPLOYMENT legislation has implications that are far-reaching, confusing, and sometimes contradictory. In times like the present we find it difficult to prevent an outraged sense of social justice from leading us into experiments in social reform that may bring us more of harm than of good, and destroy the rugged individuality and self-respect of a considerable number of our people. We turn from virtual slavery that exists in that great country where enforced idleness is not a grave issue to the breakdown of unemployment-insurance schemes in two others where it is desperately acute. In neither the dictatorship of a planned economy nor the pauperism of doles do we find the way of salvation. There is no cure for unemployment but work. There is no adequate substitute for thrift.

But such generalities diffuse only meager light in our present difficulties. We face a winter in which the privation and discontent that spring from idleness will dramatize vividly the unhappy plight of several millions of our people. Legislative remedies will be sought by State and Federal bodies, and the danger exists, if conditions do not vastly improve by the first of the year, that we shall find ourselves committed to one or more schemes whose ultimate effects cannot be predicted. Attempts will be made, without a doubt, to force the wealthy, and especially industry, to provide for the idle. With such prospects it behooves industry to face squarely the question of its obligation to the unemployed in that spirit of enlightened self-interest that is so fruitful in mutual benefits.

We therefore recommend for serious consideration the article to be found elsewhere in this issue on the "Obligation of Industry to the Unemployed," by James W. Hook. Mr. Hook is no impractical idealist. He has recently been appointed by Mr. Gifford asstate representative for Connecticut on the President's organization on unemployment relief. As responsible head of a profitable manufacturing plant he set himself the task of finding out three things about his business: (1) Who were his stable workers, (2) what actuarial data could be assembled as a basis for studying his own employment problem, and (3) how much of a reserve would be necessary to carry these stable workers over a period of depression. The results of his findings are summarized in his paper.

Mr. Hook's study was neither particularly difficult nor expensive. It could be repeated by thousands of plants all over the United States. The combined results would provide actuarial data for the guidance of individual and national industrial policies. With so much at stake as seems imminent in proposed legislation, it would be the better part of wisdom for industry to provide itself with facts. If legislation is inevitable, let it be wise and constructive.

## Smoke-Abatement Regulations

STATISTICS covering smoke-abatement regulations in more than 100 principal cities in the United States have recently been compiled by the A.S.M.E. Fuels Division. Commencing several years ago as part of the program of the Smoke-Abatement Committee of the Fuels Division, H. K. Kugel, smoke commis-

sioner of Cleveland, Ohio, sent out a questionnaire to cities in the United States and Canada having smoke-abatement ordinances in an endeavor to determine the nature and extent of their work. The information thus obtained was classified and has recently been brought up to date by means of a rechecking of the original data. These statistics are now available and may be found in the September 29 issue of *Power*. Copies of the tabulation may be obtained from *Power*, 36th Street and 10th Ave., New York City, at a nominal charge. Civic groups and others interested in smoke-abatement campaigns will find much interesting and useful information in the statistics.

The statistics are arranged alphabetically according to cities and cover the following: population, department head, advisory board, method of judging or comparing smoke, smoke permitted, applicability of regulations to railroad and marine plants, registration of permit, penalties for violations, annual budget, and supplementary remarks.

Cities in 32 states are represented in the statistics. The complete list contains 114 cities, 5 of which are in Canada, and 3 localities where additional territory is affected: Hudson County, N. J., with 12 cities, San Francisco, and the district immediately surrounding Boston, Mass., composed of 29 communities. New York State is most frequently represented, with 15 cities. Ohio is represented with 11, Michigan with 10, Illinois with 9, and Pennsylvania with 7 cities. The cities range in size from 31,243 inhabitants to 7 million. The Canadian cities on the list are Hamilton, Montreal, Toronto, Vancouver, and Winnipeg.

According to the statistics, there is a diversity of responsibility for enforcing smoke-abatement regulations. Sixty-eight of the communities, slightly more than half, report the name of the person in charge of the department concerned. In 25 cases the term "inspector" or "smoke inspector" is used. In 19 cities, responsibility rests with the building department, in 18 cities with the health department, in 8 with the fire, and in 7 with the police department. Seventeen cities report departmental heads as smoke departments or commissions. Other agencies acting as department heads are safety bureaus, city engineers, and boiler inspectors.

Forty-six cities report that they have no advisory boards for their smoke-abatement departments. In 27 cities such advisory boards are set up or are provided for, and in 14 of these at least one member of the board must be a professional engineer. Other municipal departments and officers reported as being represented on advisory boards are health, sanitary, safety, building, and fire departments, and mayors, aldermen, and city managers.

The Ringelmann chart is by far the most widely used method of comparing smoke densities and determining violations of ordinances. It is used in 53 of the cities reporting. The umbrascope is specified by 10 cities, while in 15 "smoke," more or less loosely designated as "dense," "black," etc., is reported. Twenty-one cities report that no method of comparison is in use. Six specify a color scale and one a density scale.

Smoke-abatement regulations apply to railroads in 62 of the cities reporting. In 5 they apply with qualifications, while "locomotives" are mentioned specifically by 9. Six cities replied "no" to this question. In 31 cities the regulations apply to marine plants, with 10 additional cities reporting some special qualifications. Nine cities replied "no."

To the question of the registration of installation permits replies of "yes" were received from 51 cities; of "no" from 22.

Twenty-nine cities report budgets for smoke-abatement work and 6 report none. The maximum annual budget reported is $68,320 (in 1930), and the minimum is $100.

In so far as penalties for violations of smoke ordinances are concerned, fines amounting to less than $100 predominate, being so reported from 84 cities. Fines up to $200 are reported by 6 cities, and up to $500 by 9. Punishment by imprisonment is provided for by 33 cities; 2 report penalties as those for misdemeanors, and 2 as those for public nuisances.

Smoke of objectionable quality is permitted in practically all cities for a certain portion of the day. In most cases this allowance is definitely specified, so many minutes in an hour, etc. Smoking during cleaning and kindling periods is also universally permitted.

In addition to the prohibition of smoke, that of soot, cinders, fly ash, dust, and other solid particles is specifically mentioned by 18 of those reporting, while fumes, vapors, acids, etc. are also specifically mentioned by 18 as being prohibited. Six report that the ordinances do not apply to private residences. Stokers are specifically mentioned as being required under certain conditions by 7 of those reporting. High-volatile coal is prohibited in 3 cities. Motor-vehicle exhausts are mentioned three times.

## Oil-Pollution Legislation

IN ITS report, the American Engineering Council's Joint Committee on Oil Pollution, formed to study two identical bills before Congress that propose amendments to the oil-pollution act of 1924 and provide extension of the powers of this act to cover land as well as floating structures, and of its jurisdiction to all navigable rivers and their tributaries, considers the bills "unnecessary and inadvisable forms of legislation," and is "strongly of the opinion that further extension of Federal jurisdiction and control. . . . is most undesirable."

The Committee's report is based on the results of a questionnaire directed to 44 state sanitary engineers in which two questions were asked: (1) Is oil pollution increasing in your state? and (2) is the present state machinery sufficient to take care of the situation? A majority of the 42 officers who answered felt that oil pollution was decreasing and that present state machinery was amply sufficient to take care of the situation. Information received by the Committee gave gratifying evidence of the effectiveness of voluntary control. It developed, for example, that much had been accomplished in interstate control by the Ohio River Board of Engineers and the Great Lakes Board of Engineers. It was also shown that the American Petroleum Institute, which conducted a survey of waste disposal in 1927, had recently issued a manual dealing with the disposal of refinery wastes. This is an indication of the enterprise of an industry in trying to correct practices for which it has been criticized. Similarly, the American Steamship Owners Association has been able, through cooperative effort, to improve conditions in coastal waters and harbors.

Unintentional pollution resulting from accidents on land and sea has been a cause for complaint in some instances. The remedy in such cases is obviously not a matter for legislation, but must be attacked as a technical problem.

The Committee has reached the gratifying conclusion that, in so far as intrastate and interstate waters are concerned, oil pollution is on the decline and control of the situation is satisfactory. Where control has not been exercised, laxity on the part of the state is to blame. Federal agencies appear to have sufficient control of pollution of navigable territorial waters where state and interstate supervision cannot be effective. In coastal waters there also appears to be a decline in pollution, and here Federal jurisdiction and international understanding are at hand.

In the matter of the proposed amendments to the existing bills, therefore, it may be concluded that this is one of those cases where voluntary control and self-regulation are accomplishing as much as could be expected from further extensions of Federal control and jurisdiction.

# Book Reviews and Library Notes

**THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Trustees, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.**

**The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.**

## "Shimmy" in Automobiles

SCHWINGUNGEN IN AUTOMOBILLENKUNGEN ("Shimmy"). Bericht der Versuchsanstalt für Kraftfahrzeuge und des Festigkeitslaboratoriums der Technischen Hochschule zu Berlin. By G. Becker, H. Fromm, and Maruhn. M. Krayn, Berlin, 1931. Cloth, 8 × 11 in., 150 pp., illus., diagrams, charts, tables, 15 r.m.

REVIEWED BY R. P. KROON[1]

THIS book is the result of a systematic analysis of the vibrations of front axle and front wheels of automobiles and of numerous tests made in the laboratories of the Technische Hochschule in Berlin. A complicated problem is treated with great skill; this and the fact that it is closely related to many other vibration problems make it extremely interesting to mechanical engineers.

In their introduction, the authors consider the classical examples of forced vibrations with linear spring force and viscous friction. As the results obtained under these assumptions fail to explain many forced-vibration phenomena, they develop graphical methods for cases where the spring force is a non-linear function of the displacement and where the damping factor varies with the amplitude. Attention is paid to self-induced vibration, where, due to what amounts to negative damping, vibrations are built up.

The movement of the front axle is described by three translating motions and by rotations about three axes. Moreover, the wheels can oscillate about their steering spindles. A "vibration analyzer," designed by Fromm, is used in order to record these movements separately.

All these motions are not independent of each other (coupled vibrations). Coupling between oscillation of the wheels' sidewise motion and rocking of the front axle is accomplished by the gyroscopic effect of the wheels. The authors show that oscillation of the wheels can be considerably decreased by placing masses, rotating oppositely to the wheels, on the bearing axles.

A special construction ("crosswise steering") has been designed by Maruhn in such a way that the gyroscopic effects of the two wheels compensate each other. As at the same time the rigidity of the system is increased, this construction reduces the amplitude of oscillation for normal speed to 10 per cent of the usual value.

The authors point out that the vibrations consist partly in forced vibrations due to unbalance, unroundness of the wheels and non-uniform elasticity of the tires, and partly in vibrations of natural frequency built up due to negative damping in the system. Mathematically it was found that sidewise flexibility of wheel and tire and skidding enable the wheels to take up the energy necessary to build up these self-induced vibrations.

Tests were made on two special models, the wheels being driven by rotors placed under the axle.

The results are in very good agreement with the theory.

[1] Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

## High-Speed Internal-Combustion Engine

THE HIGH-SPEED INTERNAL-COMBUSTION ENGINE. By Harry R. Ricardo. Blackie & Son, Limited, London and Toronto, 1931. Cloth, 6½ × 9⅝, 436 pp., 292 figs., $9.

REVIEWED BY OLIVER F. ALLEN[1]

THIS is a revised and extended edition of Vol. 2 of Mr. Ricardo's "The Internal-Combustion Engine," of 1923. The author believes progress in the seven intervening years has taken the form of improving and consolidating existing orthodox designs, along lines foreshadowed in the original volume; consequently the new edition contains additions rather than alterations. He considers the achievement of the high-speed Diesel the only important new development and has added a chapter dealing with it.

While restricted to consideration of the four-stroke-cycle engine, and the problems and limitations of the design and performance of engines having relatively small cylinders, running at both high rotative and high piston speeds, much in this book is so fundamental and broad in its application that it is of almost equal value in studying the larger, slower-speed engines, especially Diesels. Before 1915 the automotive type internal-combustion engine had been applied generally to services having only low and intermittent load factors. The much more severe military requirements of 1915–1918, for air services, land, and marine transportation, including tanks, and small portable lighting and power units, brought about a most intensive study and improvement of the high-speed engine. This was probably done most lavishly and perhaps most thoroughly in England where public and private resources were effectively combined. It was largely as a result of this unusual situation that Mr. Ricardo and his associates were able to make such a remarkable collection of reliable experimental data. It was his own broad and intelligent grasp of the art, plus his ability to express him-

[1] Consulting Engineer, New York, N. Y. Mem. A.S.M.E.

self clearly and concisely, which produced this well-digested résumé of that mass of data and disclosed its relation to general principles.

To the many who, because they have been working along specialized lines or because of lack of opportunity or time, have been unable to study the broader aspects of the design and performance of the gasoline engine and the fuels which it burns, this book offers a comprehensive exposition of the subject. Now that injection-type engines, such as Diesels or some modification of them, are getting into the fields of the carburation, or gasoline, engine it is necessary for engineers to understand the relations between these types. The chapter on high-speed Diesels gives their similarities and differences more clearly and concisely than we have seen them compared before.

The author predicts a shortage of both gasoline and benzol (benzene and other coal-tar distillates), but expects alcohol to take their places. Even greater output can be had with alcohol and it is equally good for the highest speeds. He thinks this tendency toward more expensive fuels will bring about higher efficiencies including lower fuel consumption. The chapter on volatile liquid fuel shows the care taken in making tests and collecting data. He reviews the problems of detonation and indicates that improved design is better than anti-knock mixtures.

The chapter on mechanical design begins with this statement: "In the design of an internal-combustion engine, as in all creative work of this nature, the aesthetic side must not be overlooked. In the first place, beauty of form and of proportions is in itself an admirable guide to mechanical correctness; for mankind has come to regard as beautiful that which is mechanically correct, whether it be in nature, in architecture, or in engineering.

"In general, beauty and efficiency—in the widest sense of the term—are synonymous, and the appeal of any design to the aesthetic sense is often as reliable a guide as is a mathematical analysis of its mechanical features."

This, taken with that on form of combustion chambers and the references to combustion chambers in the Diesel chapter, should be read by every engine designer, even if he does not agree with this author. The data given regarding turbulence, distribution of heat, supercharging, combustion propagation, and operating pressures and temperatures are also very instructive. The parts dealing with piston design and sleeve valves are commended to the attention of those who still think that the conventional trunk pistons and poppet valves are fixtures for all four-cycle designs.

Mr. Ricardo points out that from 1922 to 1930 aero engines of the same general design have increased 40 per cent in power output, and improved some 300 per cent in time between overhauls, as a result of detailed application of the progress in metallurgy and in the technique of manufacture. One may conclude from his treatise that advances of the same order are to be expected in high-speed Diesels in the next few years.

## Technical Institutes

A Study of Technical Institutes. A Collateral Project to the Investigation of Engineering Education. By The Society for the Promotion of Engineering Education, 1931. The Lancaster Press, Lancaster, Pa. Paper, 281 pp., 30 figs., $1.

TECHNICAL institutes are so few in number among the educational agencies of the United States and so little known by this name that few persons have a clear conception of their functions and characteristics. For this reason, and because of their potential value in the educational organization of an industrial nation, the report of a study of them conducted under the auspices of the Society for the Promotion of Engineering Education as a collateral project to its extended investigation of engineering education is a valuable and much-needed document. It will be recalled that Robert H. Spahr presented the preliminary findings of this study at the Annual Meeting, 1928, of the American Society of Mechanical Engineers.

Piecing together the essential characteristics of this type of educational agency from the report, the Technical Institute appears to be a school of post-secondary character that trains for jobs between those of the skilled crafts and the highly scientific professions. It provides specialized and intensive training for those who know what they want to do in technical pursuits concerned with planning and control, but more generally in supervisory pursuits concerned with operation and maintenance. It is not a preparatory school; its requirements are less formal than those of academic institutions; it stresses capacity and experience; its teaching methods are direct, a high proportion of its work being done at the school rather than by means of book study; its teachers require practical experience, personal sagacity, and ability to teach through programs of orderly experience; and its scheme of instruction follows much more closely the actual usage of industry than that of the professional engineering school. Examples of this type of educational institutions are Ohio Mechanics Institute, Pratt Institute, Westinghouse Technical School, and Pennsylvania State College Extension.

The summary of principal findings and conclusions reveals the following:

(1) Industry must look increasingly to technical schools rather than to its rank and file for its technical and supervisory personnel.

(2) There exists a need for schools having definite purposes and clearly visualized aims.

(3) Manufacturing industries having normal requirements for engineering-college graduates amounting to from 2.2 to 3 per cent of their total forces, need employees having 2 years' training above the secondary-school level approximating 6 to 8.3 per cent of the same total.

(4) The demand for the product of the technical institute exceeds the supply.

(5) A technical institute should thrive in most cities of 50,000 population or more.

(6) There is a danger for the technical institute to drift into the college field if its aims are not clearly visualized.

(7) The technical institute needs a director and staff intimately in touch with industry.

(8) It is difficult to maintain an efficient staff for evening work unless the school is an auxiliary to a day school or a large industrial establishment.

(9) The cooperative plan is well adapted to the technical institute.

(10) The geographical field for the technical institute is east of the Mississippi and north of the Ohio and Potomac rivers, with a secondary field on the Pacific coast.

(11) The needs of the United States could scarcely be met by less than 250 institutes. A chain of community institutions having an organic place in city and state educational systems, yet free to achieve their own distinctive character, seems to be indicated.

(12) The largest field for the institute is in training men in the technology of particular industries; such as textiles, foundry, machine production, building construction, etc.

(13) Lack of solidarity among existing technical institutes has retarded development of similar schools over the country at large.

(14) Technical institutes are handicapped by the fact that

their graduates receive no nationally recognized educational credentials.

A reading of the report affords convincing evidence of an educational opportunity that is being neglected by educators and industrialists alike. Greater familiarity with the needs for training of the character offered by the technical institute will probably result in developing a much-neglected element of the educational facilities of our industrial civilization.

## Books Received in the Library

DIE ANWENDUNG DER NOMOGRAPHIE IN DER MATHEMATIK. By H. Schwerdt. J. Springer, Berlin, 1931. Cloth, 6 × 10 in., 116 pp., charts, diagrams, tables, cloth, 28 r.m.

This book contains 104 charts containing 236 nomograms of various mathematical formulas, which illustrate the possibilities of nomographic methods in mathematics. The text explains the charts and shows how they may be used. A brief bibliography is included.

BAHNHOFSANLAGEN. II. SAMMLUNG GOSCHEN BD. 1036. By H. Wegele. Walter du Gruyter & Co., Berlin and Leipzig, 1931. Cloth, 138 p., illus., diagrs., tables, 6 × 4 in., 1.80 r.m.

A concise description of the construction and equipment of railroad stations and terminals. Freight- and passenger-station buildings, train sheds, shops, water supply, etc. are discussed.

DIE BETRIEBSUNTERSUCHUNG WEGE UND FORMEN. By O. Bredt. V.D.I.-Verlag, Berlin, 1931. Paper, 8 × 12 in., 56 pp., charts, tables, 12 r.m.

Dr. Bredt discusses the development of management research in America and Europe and presents a detailed description of the methods used in five typical cases. These cases are then criticized in detail, and the efficacy of the methods used is discussed. The general principles and methods of procedure are then demonstrated by reference to an investigation by the National Board of Economics of Germany. The book shows the possibilities of management research and is a brief compendium of methods.

BRENNSTOFFTECHNISCHES PRAKTIKUM. By M. Dolch. Wilhelm Knapp, Halle (Saale), 1931. Paper, 6 × 9 in., 148 pp., illus., diagrams, charts, table, 9.80 r.m.

Instead of numerous methods for determining individual constituents of a fuel, this manual indicates a systematic routine for analyzing coal, which will lead to a complete picture of a fuel. The analytical methods have been carefully selected for accuracy and rapidity, and cover all those needed for the practical analysis of coal and its direct products.

BRONZE UND ROTGUSS, nach DIN 1705. V.D.I.-Verlag, Berlin, 1931. Paper, 6 × 8 in., 100 pp., illus., diagrams, charts, tables, 7 r.m.

Contains the papers and discussions presented at a meeting of the Society of German Engineers devoted to the properties and use of the standard German bronzes and red brasses. The structure and properties of brass and bronze castings, and the standard compositions are discussed, and the experiences of various users are presented. Methods of testing are given. A bibliography for the years 1921 to 1930 is included.

L'EMPLOI DES UNITÉS DANS LA PRATIQUE DES CALCULS. By F. Bétrancourt. Dunod, Paris, 1931. Paper, 6 × 9 in., 91 pp., tables, 16 fr.

A collection of the geometrical, mechanical, electrical, magnetic, and optical units of measurement, with definitions, formulas, etc., intended as an aid to calculators.

CREEP OF METALS. By H. J. Tapsell. Oxford University Press, London, 1931. Cloth, 6 × 10 in., 285 pp., illus., diagrams, charts, tables, 30 s. (American Price $12.00).

A very complete presentation of the data available upon the creep of metals at high temperatures. The work of the various investigators has been correlated, in the light of the testing methods used by them, with the aim of enabling the engineer to a satisfactory interpretation of present and future data, and the successful use of them.

DRUCKWECHSEL UND STÖSSE AN KOHLBENMASCHINEN MIT SCHUBKURBELGETRIEBE. One vol. text and one vol. tables. By F. Kuba. Julius Springer, Vienna, 1931. Paper, 9 × 14 in. 69 pp., diagrams, tables, 18 r.m.

A theoretical investigation of the phenomena accompanying reversals of pressure in reciprocating engines. The author develops a method of determining the relative velocity of the various phenomena, analyzes these phenomena into special components, and points out the effect of changes in the conditions upon the relative magnitudes. The investigation aims to afford a sound basis for studying shocks in engine bearings, etc. A critical review of previous publications on the subject is included.

DYNAMICS OF AIRPLANES AND AIRPLANE STRUCTURES. By J. E. Younger and B. M. Woods. John Wiley & Sons, N. Y., 1931. Cloth, 6 × 19 in., 263 pp., diagrams, charts, tables, $3.50.

A textbook on this increasingly important branch of aeronautical engineering, intended for senior or graduate students and practicing engineers. A working knowledge of the calculus and training in engineering mechanics are assumed. The book aims to act as a guide to and interpreter of the literature of advanced dynamics. The methods of solving problems of mechanics are first discussed, after which the dynamics of airplanes is treated. Finally, the airplane structure is treated as an elastic structure, and the equations of equilibrium are applied to various problems of vibration.

ECONOMICS FOR ENGINEERS. By E. L. Bowers and R. H. Rowntree. McGraw-Hill Book Co., N. Y., 1931. Cloth, 6 × 9 in., 490 pp., diagrams, charts, maps, tables, $4.

This textbook on economics has been written to give engineering students a knowledge of economic principles and problems. The subject is presented very concisely, in order not to burden the curriculum unduly, and the engineering aspects of economic theory and business activity are emphasized. A practical presentation of the subject from an engineering point of view.

FORSCHUNGSHEFT 344. Thermodynamische Rechnungsgrundlagen der Verbrennungskraftmaschinen und ihre Anwendung auf den Höhenflugmotor. By A. Hansen. V.D.I.-Verlag, Berlin, 1931. Paper, 9 × 12 in., 28 pp., diagrams, charts, tables, 5 r.m.

The theoretical diagram of an internal-combustion engine, as obtained by thermodynamic calculation, applies only to the case under consideration and gives no indication of the effect of variations in operating conditions upon the curve. The tables here presented give values for the cardinal points of the theoretical diagrams, the mean indicated pressures and the theoretical efficiencies. They enable the designer to see the functional relations and to avoid new calculations if service conditions change.

In the second part of this research these results are used to determine the thermodynamic limits of high-altitude aviation engines and to study the best processes of working for high-altitude flight.

FORSCHUNGSHEFT 346. WÄRMESPANNUNGEN IN GLEICHDRUCKWÄRMESPEICHERN. By E. Meyer. V.D.I.-Verlag, Berlin, 1931. Paper, 9 × 12 in., 23 pp., diagrams, charts, 5 r.m.

This research report deals with an experimental and theoreti-

cal investigation of the heat stresses in steam accumulators of the constant-pressure type. The work was done at the Karlsruhe Technical University.

FORSCHUNGSHEFT 347. STAUBAUSSCHEIDUNGEN AN EINFACHEN KÖRPERN UND IN LUFTFILTERN. By W. Sell. V.D.I.-Verlag, Berlin, 1931. Paper, 9 × 12 in., 23 pp., illus., diagrams, charts, tables, 5 r.m.

The author studies the laws governing the deposition of dust from gas currents both theoretically and experimentally. Formulas for the flow of dust are derived and the deposition of dust upon cylinders, plates, and baffles calculated. The behavior of air filters is investigated in the same way and a general formula derived.

GEOMETRIE DER GETRIEBE. By K. Mack. J. Springer, Berlin & Vienna, 1931. Paper, 6 × 10 in., 93 pp., diagrams, 8.50 r.m.

The geometrical bases of the theory of gear teeth are presented here in the manner used by the author in his courses to engineering students at the Prague Technical University. The course is intended to supplement the usual elementary instruction in descriptive geometry by combining that subject with kinematics in a practical way.

GRAPHISCHE DARSTELLUNG IN WISSENSCHAFT UND TECHNIK. Sammlung Goschen. Bd. 728. By M. Pirani. Walter de Gruyter & Co., Berlin & Leipzig, 1931. Cloth, 4 × 6 in., 149 pp., diagrams, charts, tables, 1.80 r.m.

A brief simple introduction to the construction and use of nomograms and other graphic charts. A good brief bibliography is included.

INDUSTRIAL ORGANIZATION. By H. Rubey. Ginn & Co., Boston and N. Y., 1931. Cloth, 6 × 9 in., 308 pp., diagrams, charts, tables, maps, $2.80.

A brief but comprehensive course covering such fundamentals of business as promotion, finance, management, organization, marketing, personnel, accounting, estimating, valuation, etc. The book is intended primarily to give the engineer some knowledge of business, as preparation for executive and managerial work. It will also be useful to others who wish a general survey of this field.

INHALTSVERZEICHNIS DER ZEITSCHRIFT DES VEREINES DEUTSCHER INGENIEURE, 1926–1930. Bd. 70–74. V.D.I.-Verlag, Berlin, 1931. Paper, 8 × 12 in., 138 pp., 8 r.m.

This index, covering the last five volumes of the *Zeitschrift*, contains over 3500 entries to authors and subjects, and is an important guide to recent engineering developments, especially to the work of German engineers.

INTERNATIONAL CRITICAL TABLES OF NUMERICAL DATA, PHYSICS, CHEMISTRY, AND TECHNOLOGY. Index vols. 1–7. By the National Research Council. McGraw-Hill Book Co., New York, 1930. Paper, 9 × 11 in., 43 p.

An index to the complete set, published in four languages: English, French, German, and Italian.

INTERNATIONAL CRITICAL TABLES OF NUMERICAL DATA, PHYSICS, CHEMISTRY, AND TECHNOLOGY. Vol. 7. By the National Research Council. McGraw-Hill Book Co., N. Y., 1930. Cloth, 9 × 11 in., 507 pp. ($84 for seven volumes, of which this is the last.)

This is the final volume of this work, in which the best values for an immense number of constants and numerical data of physics, chemistry, and engineering are recorded for the convenience of research workers. The values are based upon all the recorded work of the world previous to 1924, as recorded in the "Annual Table of Constants and Numerical Data." The values given in the present work have been chosen by competent authorities as the most satisfactory. References to the original publications are included. The work is indispensable in research laboratories and libraries of science.

KONSTRUKTION UND BERECHNUNG MODERNER AUTOMOBIL- UND KRAFTRADMOTOREN. By C. Riedl. R. C. Schmidt & Co., Berlin, 1931. Cloth, 7 × 10 in., 776 pp., illus., diagrams, charts, tables, 42 r.m.

The design and construction of automobile and motorcycle engines are here presented in detail. Two-cycle and four-cycle air-cooled and water-cooled engines are discussed in a practical way, and illustrated by many examples of European and American types.

KURZES LEHRBUCH DES DAMPFLOKOMOTIVBAUES. By F. Meineke. J. Springer, Berlin, 1931. Paper and bound, 6 × 10 in., 222 pp., diagrams, charts, tables, paper, 16.50 r.m.; bound, 18 r.m.

The aim of this textbook is to give a simple account of the theoretical principles underlying the construction of the steam locomotive of the ordinary type. While intended for locomotive builders, attention is directed to the reasons for the usual design of the machine rather than to locomotive building. The work is a concise practical text on the theory of locomotive design.

LECTURES ON THEORETICAL PHYSICS DELIVERED AT THE UNIVERSITY OF LEIDEN. By H. A. Lorentz. Macmillan & Co. Ltd., London, 1931. Cloth, 6 × 9 in., 326 pp., diagrams, charts, tables, $7.

This, the final volume of the translation of Lorentz's lectures on theoretical physics, contains his work on Maxwell's theory, and upon the principle of relativity for uniform translations, or special theory of relativity.

MATERIALS OF CONSTRUCTION. By A. P. Mills. Fourth edition, edited by H. W. Hayward. John Wiley & Sons, New York, 1931. Cloth, 6 × 9 in., 423 pp., illus., diagrams, charts, tables, $4.

The aim of this work is to supply a general textbook upon the manufacture, properties, and uses of the common engineering materials, for students of engineering. The book is to be supplemented by a laboratory course in the testing of materials. The new edition has been revised and enlarged.

MECHANISM. By R. M. Keown and V. M. Faires. Third edition, McGraw-Hill Book Co., N. Y., 1931. Cloth, 6 × 9 in., 242 pp., illus., diagrams, charts, tables, $2.50.

Professor Faires has modernized this well-known textbook. The chapters have been rearranged and the number and variety of the problems increased. The chapters on gearing have been rewritten and extended, and the book as a whole is slightly enlarged, but the original aim of a simple, clear presentation of the subject, suitable for a one-semester course, has been retained.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN, GHH-KONZERN. Bd. 1, Heft 5, pp. 101–122, May, 1931. V.D.I.-Verlag, Berlin. Paper, 9 × 12 in., illus., diagrams, charts, tables, 3 r.m.

The first article in this bulletin discusses the use of large Diesel engines in electric power plants. Their advantages for peak-load service and as standbys are shown. The bulletin also reports on investigations of methods of drying wood and their effects upon its mechanical properties.

MODERN COMBUSTION. COAL ECONOMICS AND FUEL FALLACIES. By C. V. Beck. Mid-West Coal Retailer, Chicago, 1931. Leather, 7 × 11 in., 382 pp., illus., diagrams, charts, maps, tables, $3.00.

The author is president of a company mining coal in Illinois and his book is an exposition of the advantages of coal in comparison with other fuels. Proper methods of using coal for heat and

power are explained, the principles of combustion are presented, and the relative cost of different fuels is discussed. The book is intended for coal men, building owners and managers, and others interested in the economical production of heat and power, who wish a simple, non-technical account.

ONWARD INDUSTRY! By J. D. Mooney and A. C. Reiley. Harper & Brothers, New York and London, 1931. Cloth, 6 × 10 in., 564 pp., $6.

In an endeavor to discover and define the principles of efficient organization, the authors have had the happy idea of studying principles used by the great political, military, and ecclesiastical organizations of the past. This historical review of human experience with large organizations is accompanied by a study of present problems of coordination and operation in modern industrial corporations. The result is an unusual book.

POWER AND THE INTERNAL COMBUSTION ENGINE. By W. E. Dalby. Longmans, Green & Co., New York, 1931. Cloth, 6 × 9 in., 280 pp., diagrams, charts, tables, $7.

Professor Dalby here treats of the common principles of the internal-combustion engine. The first chapter is devoted to the physical and thermodynamical properties of a working agent formed from a gaseous charge by explosion. The second chapter considers in more detail fuels and the charges formed by mixing them with air, and the products of their combustion. The engine and its performance are the subject of chapter four, which is followed by a chapter on the performance diagram devised by the author. Succeeding chapters are devoted to the suction gas plant, the gasoline engine, and the effect of heat flow on design. The book contains much to interest the designer.

PRAKTISCHE GETRIEBELEHRE. By K. Rauh. First volume. J. Springer, Berlin, 1931. Cloth, 6 × 9 in., 139 pp., illus., diagrams, charts, 22.75 r.m.

In this book mechanisms are not discussed from the point of view of the mathematician or student of theoretical mechanics, but from that of the practical designer of machinery. It is intended to give him a general knowledge of the possible mechanisms, to show their interrelations and transformations, the effects of changed dimensions, etc. and to illustrate the ways in which they may be applied. The treatment is non-mathematical.

Volume one is confined to four-link chains, which are discussed comprehensively. The numerous illustrations are unusually clear and understandable, and include eight charts in colors.

PRINCIPLES AND PROBLEMS OF AIRCRAFT ENGINES. By M. M. Farleigh. John Wiley & Sons, New York, 1931. Cloth, 6 × 9 in., 277 pp., illus., diagrams, tables, $3.

A practical, non-technical handbook on the servicing of aircraft engines, intended for mechanics and aviators. Methods of timing valves and ignition, of carburation and lubrication, etc. are described. The location of troubles is discussed, and the methods of overhauling several typical engines are given. A glossary of terms is included.

LES PROCÉDÉS MODERNES DE TAILLE DES ENGRENAGES. By J. Perignon. Dunod, Paris, 1931. Paper, 6 × 8 in., 95 pp., illus., diagrams, charts, tables, 22 frs.

This handbook describes modern methods of gear cutting and the principal gear-cutting machines in use.

SCIENCE AND RELIGION, a Symposium, with a foreword by M. Pupin. Charles Scribner's Sons, New York, 1931. Cloth, 5 × 8 in., 175 pp., $1.75.

In the fall of 1930 the British Broadcasting Corporation arranged a series of talks, in which eminent scientists, churchmen, and philosophers were asked to give their personal interpretation of the relation of science to religion and to determine to what degree the conclusions of modern science affect religious dogma and the fundamental tenets of Christian belief. These addresses now appear in print, with a foreword by Professor Pupin, and are of unusual interest as a representation of the mature thought of distinguished leaders in the two fields.

Among the twelve contributors are Sir J. Arthur Thomson, Julian Huxley, Sir Arthur Eddington, the Bishop of Birmingham, Dean Inge, and Canon Streeter.

SEEING, A PARTNERSHIP OF LIGHTING AND VISION. By M. Luckiesh and F. K. Moss. Williams & Wilkins Co., Baltimore, 1931. Cloth, 6 × 9 in., 241 pp., illus., diagrams, charts, tables, $5.

Seeing depends upon light and lighting, as well as upon the eyes and the visual sense; yet light and lighting have not yet received much consideration as a partner of the visual sense, the authors assert, although excellent scientific data pertaining to vision are available. The present book aims to remedy this lack, in part, by giving the results of extensive research work, covering some twenty years and undertaken to establish the scientific principles of seeing. A bibliography is included.

SELBSTKOSTENRECHNUNG EINES WERKES DER KUPFERHALBZEUGINDUSTRIE. By W. Moeller. V.D.I.-Verlag, Berlin, 1931. Paper, 6 × 9 in., 132 pp., charts, tables, 10 r.m.

A detailed study of methods of cost accounting as used at present in works engaged in rolling, forging, and drawing copper, with respect to their suitability. The book is based upon personal experience.

STEAM TURBINE OPERATION. By W. J. Kearton. Isaac Pitman & Sons, London and N. Y., 1931. Cloth, 6 × 9 in., 300 pp., illus., diagrams, charts, table, $3.75.

Such topics as the installation of turbines, their heating and drainage, turbine glands and sealing arrangements, lubrication, governing, starting and stopping, inspection and overhauling, and testing are discussed in a practical way. One chapter is devoted to troubles, and another to the Ljungström turbine.

UEBER DEN SPANNUNGSZUSTAND EINSEITIG AUFGEBRACHTER LASCHEN IM BAU VON ZELLSTOFFKOCHERN. By E. Höhn. J. Springer, Berlin, 1931. Paper, 6 × 9 in., 84 pp., illus., diagrams, charts, tables, 4.80 r.m.

A report on an experimental investigation of the stresses in riveted joints with butt straps upon one side only, as is the custom in wood-pulp digesters. Descriptions of several explosions of digesters are also included, and conclusions drawn from them. The work was done at the instance of the Swiss Association of Boiler Owners.

VECTOR ANALYSIS. By L. R. Shorter. Macmillan & Co., London and New York, 1931. Cloth, 5 × 8 in., 356 pp., diagrams, $2.75.

The extensive use of vector methods in modern textbooks of physics makes it necessary for the student of mathematical physics to have a working knowledge of vector analysis. This brief text is intended to supply that need. It is also suited for use as an introduction to the subject for students of mathematics.

VERGLEICHENDE UNTERSUCHUNG VON TROCKENSTOFFEN. (Fachausschuss für Anstrichtechnik, Heft 12.) By H. Wolff, in collaboration with W. Toeldte, P. B. Rosen, M. Iscovitch. V.D.I.-Verlag, Berlin, 1931. Paper, 9 × 12 in., 30 pp., charts, tables, 4.50 r.m.

This report presents the results of a careful study of various paint driers. The process of drying is described, and the effect of storage, moisture, pigment, and light upon the drying of the various compounds is investigated. The methods of investigation are described and the results stated.

# Current Mechanical Engineering Literature

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### AERIAL TRANSPORTATION

**Pilots' Problems.** The Problems of Air Transport From the Pilot's Point of View, N. Macmillan. Cinquième Congrès International de la Navigation Aérienne (5th International Congress of Avigation), vol. 1, Sept. 1–6, 1930, pp. 200–215 and (discussion) 216–228. (In English.)

**Radio Communication.** Communication on Civil Airways in Canada, W. A. Steel. Eng. Jl., vol. 14, no. 7, July 1931 pp. 409–415, 10 figs. Survey of various systems of communication applicable to aircraft and airways; radio aids to air navigation; directive beacon and direction-finding equipment; as means of two-way communication with aircraft in flight, radio telegraphy is considered more effective and reliable than radio telephony; in order to permit of continuous service, blind landing equipment is required; use of radio beams for this purpose; present system of communicating meteorological reports by teletype and existing organization of civil airways in Canada.

Ueber die Zweckmaessigkeit der Telegrafie und Telefonie im Flugfunkverkehr mit Berueck-sichtigung Neuer Experimenteller Untersuchungen (Suitability of Telegraphy and Telephony in Aerial Communication With Special Regard to Recent Experimental Research), F. Eisner. Cinquième Congrès International de la Navigation Aérienne (5th International Congress of Avigation), vol. 1, Sept 1–6, 1930, pp. 83–109 and (discussion) 109–110, 23 figs. Quantitative values entering in transmission and interference level; special requirements of radio telephony and telegraphy communication in aviation; equipment; comparison between telephone and code communication. (In German.)

### AIR CONDITIONING

**Equipment.** A Modern Air Conditioning Plant. Machy. Market, no. 1600, July 3, 1931, p. 25, 1 fig. New Siroco equipment for automatic control of temperature and humidity, introduced by Davidson and Co., of Belfast.

### AIRPLANE ENGINES

**Air-Cooled.** Air-Cooled Compression Ignition Aero Engines, A. H. R. Fedden. Cinquième Congrès International de la Navigation Aérienne (5th International Congress of Avigation), vol. 1, Sept. 1–6, 1930, pp. 797–805 and (discussion) 805–806, 3 figs. Experience of Bristol Co., England, with deductions as to future type. (In English.)

**Cooling.** The Cooling of Engines, A. Nutt. Aircraft Eng., vol. 3, no. 29, July 15, 1931, pp. 172–173, 8 figs. Experiments undertaken to show possibilities of high temperature liquid cooling; effect of changing compression ratio on horsepower at different outlet temperatures; horsepower curves showing result of changing compression ratio and outlet temperature; brake mean effective pressures resulting from changes in compression ratio and temperature.

**Cowling.** Some Experiments on Nacelles With Townend-Rings, C. Koning and H. J. Van Der Maas. Cinquième Congrès International de la Navigation Aérienne (5th International Congress of Avigation), vol. 1, Sept. 1–6, 1930, pp. 568–573 and (discussion) 573–574, 3 figs. Model experiments were made with nacelle of twin-engined aeroplane with and without these rings. (In English.)

Effect of Ring Type Engine Cowls on Model of Douglas XO-14, Five Foot Wind Tunnel Test No. 35. Air Corps Information Cir., vol. 7, no. 659, Apr. 1, 1931, 6 pp., 6 figs. Test in 5-ft. wind tunnel at air speed of 80 m.p.h.; complete tables of lift and drag data.

**Diesel.** Recent Progress in Compression Ignition Engines, A. Swan. Aeroplane, vol. 41, no. 5, July 29, 1931, pp. 316, 318 and 320, 5 figs. Relative economy of heavy-oil engine against gasoline engine; main disadvantage of former is in increased weight; applicable to long-distance flying because of simplicity of fuel storage.

Guiberson Diesel Motor Production Plans. South. Aviation, vol. 2, no. 11, July 1931, p. 38, 1 fig. Nine-cylinder radial air-cooled experimental engine designed by F. A. Thaheld, weighing 502 lb. and developing 240 hp. at 2000 r.p.m.

**Helicopters.** See HELICOPTERS.

**Hirth.** 50–60 PS-Hirth-Vierzylinder-Flugmotor (50–60 Hp. 4-Cylinder Airplane Engines). Deutsche Motor-Zeit., vol. 8, no. 6, June 1931, pp. 207–210, 5 figs. Specifications in-line inverted air-cooled engines of 100 to 110 mm. bore and stroke and developing 65 maximum hp. and 2100 r.p.m.; weight 82.3 kg., fuel consumption 225 grams per hp. hr.

**Light.** Brownback "Bumble Bee" Three-Cylinder Light Aircraft Engine Is Air Cooled. Automotive Industries, vol. 65, no. 2, July 11, 1931, p. 49, 1 fig. Radial design of 3½ by 4.13 in. bore and stroke, rated at 25 hp. at 1600 r.p.m. and capable of 30 hp. 1800 r.p.m.; weight with accessories 99 lb.

**Maintenance and Repair.** Engine Service and Maintenance—X, J. G. Thompson. West. Flying, vol. 10, no. 1, July 1931, pp. 40–42 and 75, 5 figs. Routine maintenance methods and inspection procedure for 5 and 7 cylinder LeBlond engines of from 60 to 110 hp.; data on ignition, valve timing, carburetion, lubrication, and important engine clearances.

**Starters.** A New Engine Starter. Automobile Engr., vol. 21, no. 282, July 1931, p. 268, 3 figs. Design of 2 hp. 12 volt Scintilla; diagram of connections and switch mechanism in starter body; performance curves.

**Valves.** Technical Description of the Salt Cooled Valve, R. Jardine. Aviation Eng., vol. 6, no. 1, July 1931, pp. 21–32, 2 figs. Design and operating principles of sodium cooled valves.

### AIRPLANES

**Ambulance.** Flugzeuge fuer den Krankendienst (Airplanes for Sick Service), A. Karsten. Gesundheits-Ingenieur, vol. 54, no. 18, May 2, 1931, pp. 280–283, 6 figs. Design and performance data of special ambulance plane with particular regard to types built by Dornier and Junkers; practical examples of their use.

**Brakes.** Aeroplane Braking Systems, R. Waring-Brown. Aircraft Eng., vol. 3, no. 29, July 1931, pp. 157–161, 30 figs. Calculation of brake lining and brake diameter; brake shoe design; load on lining; servo operation; wind resistance on wheels; Lockheed hydraulic brake system; installation of Vickers hydraulic brake; independent wheel operation; Vickers hydraulic brake controller; Palmer pneumatic brake.

**Design.** Auftriebsverteilung und Laengsstabilitaet (Lift Distribution and Longitudinal Stability), C. Toepfer. Zeit. fuer Flugtechnik und Motorluftschiffahrt, vol. 22, no. 12, June 29, 1931, pp. 366–368, 4 figs. Performance calculations for large angles of incidence based on assumption of certain disturbance in life distribution with particular regard to effect of propeller slip stream.

The Method of "Least Work" and the Stressing of Aeroplane Structures, F. G. Evans. Roy. Aeronautical Soc.—Jl., vol. 35, no. 247, July 1931, pp. 642–664, 2 figs. Calculation of strain energy of structural member; distribution of loads in non-self-strained redundant structure (theorem of least work); Hooke's law in relation to wires, struts, and spars.

Analysis of Shallow Truss Spars—I, A. S. Niles. Airway Age, vol. 13, no. 5, Aug. 1, 1931, pp. 114–116, 3 figs. Method illustrated by numerical example.

**Landing Gear.** On the Landing Load of the Aeroplane, T. Ogawa. Cinquième Congrès International de la Navigation Aérienne (5th International Congress of Avigation), vol. 1, Sept. 1–6, 1930, pp. 672–679, 4 figs. Analysis of load incurred on undercarriage using simplest case of steel spring shock absorber. (In English.)

**Maintenance and Repair.** American Airways Dallas Shops, South. Aviation, vol. 2, no. 11, July 1931, p. 7, 2 figs. Inspecting and rebuilding of motors; average of one motor per day is torn down and rebuilt like new.

**Materials.** The Construction of Aircraft in Steel, F. M. Green. Cinquième Congrès International de la Navigation Aérienne (5th International Congress of Avigation), vol. 1, Sept. 1–6, 1930, pp. 654–667 and (discussion) 667–671, 10 figs. Reasons which led to choice of steel; system of construction used; experience gained in manufacture and supply of steel aircraft during last 10 years. (In English.)

Use of Stainless Steel in Aircraft Construction. N. O. Robinson. Aviation Eng., vol. 6, no. 1, July 1931, pp. 11–14 and 19, 7 figs. Advantages of alloys steel with regard to corrosion resistance and weight saving; method of Fleetwing for testing stainless-steel airplane components; butt-welding procedure.

Light Alloys in Engine Construction, E. F. Lake. Aviation Eng., vol. 6, no. 1, July 1931, pp. 15–17, 2 figs. Comparison of strength properties of various light alloys with particular regard to magnesium alloys; inspection methods used in assembling light alloy parts of American Ensign engine.

**Propellers.** Ueber die Schwingungserscheinungen an Luftschrauben (Vibration Phenomena of Air Screws), F. Seewald. Zeit. fuer Flugtechnik und Motorluftschiffahrt, vol. 22, no. 12, June 29, 1931, pp. 369–374, 13 figs. Coupled torsional and bending vibration; vibration with one degree of freedom for greater angles of incidence; effect of curvature of propeller; test setup for observation of vibration phenomena.

Airscrew Body Interference, C. N. H. Lock. Cinquième Congrès International de la Navigation Aérienne (5th International Congress of Avigation), vol. 1, Sept. 1–6, 1930, pp. 528–544, 11 figs. Theory of interference on airscrew; analysis of body drag. Bibliography. (In English.)

**Shock Absorbers.** Dynamic Test of Long Stroke Oleo Strut With Compensating Valve. Air Corps Information Cir., vol. 7, no. 658, Apr. 1, 1931, pp. 1 and (discussion) p. 2, 2 figs. Oleo strut can absorb energy of 36 in. free drop with total weight of 1250 lb. without exceeding maximum load of 11,000 lb.; efficiency of oleo is 36.1 per cent, low figure in comparison with other hydraulic shock absorbers.

**Spinning Characteristics.** The Spinning of Aeroplanes, S. Scott-Hall. Roy. Aeronautical Soc.—Jl., vol. 35, no. 247, July 1931, pp. 609–623. Research and test work on spinning; measurement of moments of inertia; mean angle of incidence in spin; criteria for autorotation; inertia couple in spin, gyroscopic couple due to airscrew.

On the Equilibrium of Steady Spinning of Aeroplanes, R. Fukatsu. Cinquième Congrès International de la Navigation Aérienne (5th International Congress of Avigation), vol. 1, Sept. 1–6, 1930, pp. 435–448, 7 figs. Method used to attack problem of equilibrium of steady spinning; possible causes of dangerous state of equilibrium, from which airplane can not recover to normal flight by use of controls. (In English.)

**Stability.** Le prix de la stabilité longitudinale de l'avion et du "canard" (Price of Longitudinal Stability of Airplanes and of "Duck"), W. Margoulis. Aeronautique, vol. 13, no. 144, May 1931, pp. 169–171, 1 fig. Analysis of respective advantages of conventional airplane and duck type with chart illustrating coefficient of aspect ratios.

**Testing.** Uses and Limitations of Mechanical Tests, W. D. Douglas. Cinquième Congrès International de la Navigation Aérienne (5th International Congress of Avigation), vol. 1, Sept. 1–6, 1930, pp. 635–642 and (discussion) 642–643, 8 figs. Purposes of mechanical test of airplane structures and components discussed are: to assist or improve design; to check calculations or to determine structural strength for purposes of airworthiness approval; to assist in determining cause of accidents. (In English.)

The Primary Importance of Mechanical Testing in Aircraft Construction, I. J. Gerard. Roy. Aeronautical Soc.—Jl., vol. 35, no. 247, July 1931, pp. 579–608, 37 figs. Methods and machines for mechanical testing of various airplane materials and components.

Wind Tunnel Tests and Performance Calculations on the Medvedeff Monobiplane, F. K. Teichmann and B. P. Ruffner. Aviation Eng., vol. 4, no. 6, June 1931, pp. 17–21, 13 figs. Design permitting folding against side of fuselage of lower wing in flight; span 50 ft.; power plant Wright Cyclone Mod. R-1820 E 605 hp.; weight empty 420 lb.; useful load 4300 lb.; gross weight 8500 lb.

**Wings.** Comportamento aerodinamico dell'ala a sezione non costante, oppure sottopasta a corrente non uniforme e sull'effetto di fusoliera (Aerodynamic Behavior of Wing With Variable Profile Exposed to Non-Uniform Current and With Consideration of Effect of Fuselage), G. Andreoli. Cinquième Congrès International de la Navigation Aérienne, vol. 2, 1930, pp. 1002–1025. Indexed in Engineering Index 1930, p. 78, from Notiziario Tecnico di Aeronautica, Sept. 1930.

Sul comportamento Aerodinamico d ali dedotte per dedotte per deformazione da un'ala piana (Aerodynamic Characteristics of Wings Derived From Deformation of Plane Wing), G. Andreoli. Cinquième congrès International de la Navigation Aérienne, vol. 2, 1930, pp. 975–1001. Indexed in Engineering Index 1930, p. 78, from Notiziario Tecnico di Aeronautica, Aug. 1930.

L'aile Gérin à surface variable (Gérin Wings With Variable Surface). Aéronautique, vol. 13, no. 144, May 1931, pp. 188–189, 7 figs. Design of wing mechanism permitting three-fold enlargement of surface.

L'interaction des longerons dans les ailes cantilever (Interaction of Spars in Cantilever Wings), E. Abit. Aeronautique, vol. 13, no. 144, May 1931, pp. 172–176, 15 figs. Strength calculations with particular regard to torsional stresses and comparison with static test results, numerical example of effect of wing covering on strength properties of wing.

### AIR POLLUTION

**Smoke Determination.** An Instrument for Measuring the Degree of Smoke Pollution of City Air. Engineer, vol. 152, no. 3938, July 3, 1931, p. 7, 4 figs. Instrument consists of train of gearing operated by weight, somewhat on lines of clock, but having instead of escapement to regulate rate of operation, bellows which is operated by crank; although primarily designed for measuring sooty impurity, it can be applied to dusts of other colors by using filter paper of suitable color; invented by J. S. Owen.

### AIRSHIPS

**Mooring Masts.** Self-Propelling Mooring Tower Handles Akron Dirigibles. Eng. News-Rec., vol. 107, no. 4, July 22, 1931, pp. 146–147, 3 figs. Description of improved type of landing and mooring machine designed and built by Wellman Engineering Co., of Cleveland; it is 125 ton structure capable of hauling in largest airship, holding it against any wind and moving it into shed; its three crawler supports can operate on either earth or concrete floor of dirigible shed, although tower is intended mainly for outdoor service.

### ALLOYS

**Aluminum.** See ALUMINUM ALLOYS.

**Bearing Metals.** See BEARING METALS.

**Brass.** See BRASS.

**Chromium.** See CHROMIUM ALLOYS.

**Iron-Nickel.** See IRON-NICKEL ALLOYS.

**Steel.** See ALLOY STEELS.

### ALLOY STEELS

**Heat-Resisting.** Die an hitzebestaendige metallische Werkstoffe zu stellenden Anforderungen und ihre Pruefung (Requirements and Testing of Heat-Resisting Metals), O. Hengstenberg and F. Bornefeld. Kruppsche Monatshefte, vol. 12, June 1931, pp. 153–158, 3 figs. Requirements of alloys subjected to high temperatures; testing methods. Bibliography.

**Zirconium.** Zirconium Additions Improve Steel and Cast Iron. Steel, vol. 89, no. 3, July 16, 1931, pp. 41–44, 2 figs. Effect of zirconium, carbon, and manganese on heat-treated steel; percentage improvement of manganese steel with 0.10 per cent zirconium addition; effect of zirconium on manganese steel, air cooled from 15,000 deg. Fahr.

### ALUMINUM ALLOYS

**Heat Treatment.** Die Beeinflussung der Verguetung durch Recken nach dem Abschrecken (Influence of Stretching After Quenching on Quality of Aluminum Alloys), W. Fraenkel. Zeit. fuer Metallkunde, vol. 23, no. 6, June 1931, pp. 172–176, 10 figs. Investigation of improvement of aluminum alloys by kneading directly after quenching; determination of hardness and tensile strength and, in some cases, yield point and electric conductivity.

### ALUMINUM WELDING

**Progress.** Fortschritte im Aluminiumschweissen (Progress in Aluminum Welding). Metallboerse, vol. 21, no. 51, June 27, 1931, p. 1205. Gas fusion and electric arc welding; Slavanoff arc-welding process, using metallic arc; advantages of arc welding.

### AUTOGIROS

**Performance.** Performance Features of the Autogiro, W. E. Debram. South. Aviation, vol. 2, no. 7, July 1931, pp. 13–14. 3 figs. Facts about autogiro; some of its special mechanical features and flight characteristics; based on interview with E. D. Rice, executive of Autogiro Co. of America.

**Stability.** Metal Rotor of Autogiros Hinged for Stability, B. von L. Landsdowne. Iron Age, vol. 128, no. 5, July 30, 1931, pp. 302–303, 3 figs. Hinging of blades of rotor or upper wing of autogiro is reported to have made it possible to operate this unique aircraft under conditions of stability which previously could not be attained; blades of rotor, made of elliptical steel tubing, produce by their rotation unbalanced force, which without this hinging element, was found to result in considerable instability in flight.

### AVIATION

**Problems.** Has the Airplane a Future? J. W. Miller. West. Flying, vol. 10, no. 1, July 1931, pp. 21–25, 5 figs. Solution for principal problems which stand in way of airplane as means of individual transportation; planning of airway system with airport at frequent intervals along main highways; need of design with folding wings and methods of driving landing wheels.

# B

### BEARING METALS

**Graphite Addition.** Alliages antifriction graphités (Anti-Friction Alloys Containing Graphite). Aciers Spéciaux Métaux et Alliages, vol. 6, no. 68, Apr. 1931, pp. 209–211, 2 figs. Application of alloy known as "graphitonmetal France" to railroad rolling stock in France; advantages of addition of graphite to lead-base bearing metal.

### BEARINGS

**Anti-Friction.** Anti-Friction Bearings and the Power Bill, L. M. Klinedinst. Power Plant Eng., vol. 35, no. 13, July 1, 1931, pp. 716–718, 4 figs. Reduction of friction possible in all plants; specific power savings in steel mills, clay and brickmaking plants; anti-friction bearings in various types of machinery.

### BELTING

**Leather.** You Must Know About Leather to Know Good Belting, E. Perry. Indus. Transmission and Conveying, vol. 38, no. 6, June 1931, pp. 9–10 and 17–18, 1 fig. Parts of hide from which leather belting is made; process of tanning.

### BOILER FEEDWATER

**Analysis.** Boiler Feedwater Analysis and Their Interpretation, J. D. Yoder. Power, vol. 73, no. 26, June 30, 1931, pp. 1021–1023. Fundamental ionic analysis; analysis reported in combined form; ionic report with equivalents; table of molecular and equivalent weights of elements, compounds and radicals; converting combined analysis to ionic form.

**Treatment.** Kolloide und Kesselspeisewasser (Colloids and Feedwater), E. Sauer. Mitteilungen der Vereinigung der Grosskesselbesitzer E. V., no. 32, May 31, 1931, pp. 144–193, 69 figs. Salt removal; behavior of hardness-forming organisms at temperatures of 40 to 100 deg. cent. in presence of organic colloids; tests at elevated pressure; micro-organisms of precipitates formed in presence of colloids; summary of results of tests.

Salts in Boiler-Feed Water Reduce Priming, C. W. Foulk. Power, vol. 74, no. 5, Aug. 4, 1931, p. 165, 1 fig. Experimental apparatus and procedure carried out at Engineering Experiment Station, Ohio State University, Columbus, Ohio, for determination of priming reduction due to addition of salts in boiler feedwater.

Angriff von alkalischen Phosphatloesungen auf Kesselblech (Effest of Alkaline Phosphate Solutions on Boiler Plate), E. Seyb. Mitteilungen der Vereinigung der Grosskesselbesitzer E. V., no. 32, May 31, 1931, pp. 141–143. Results of investigations made at Merseburg Ammonia Works; although it was shown that solution has some effect on boiler plate, it is not of dangerous nature, and it is not deemed advisable to dispense with phosphate in feedwater in view of its scale-preventive properties.

### BOILER FURNACES

**Refractory Materials.** Furnace Walls, G. P. Reintjes. Blast Furnaces and Steel Plant, vol. 19, no. 6, June 1931, pp. 859–861, 4 figs. Causes of furnace-wall failures.

**Water-Cooled.** Die Wirtschaftlichkeit wassergekuehlter Feuerraumwaende (Economy of Water-Cooled Furnace Walls), W. Hojer. Waerme, vol. 54, no. 27, July 4, 1931, pp. 522–527, 12 figs. Based on laws of radiation, principal arrangements of cooled heating surfaces are investigated with regard to their economy; factors governing economy of cooling surfaces; curves for determination of minimum costs.

### BOILERS

**Control.** Automatic Combustion Control, C. H. Sanderson and E. B. Ricketts. Am. Inst. Elec. Engrs.—Advance Paper, no. 92, for mtg. June 22–26, 1931, 8 pp., 15 figs. Historical; outline of Bailey system, Engineer Co. system,

Leeds and Northrup system, and Smoot system; reasons for automatic control; adapting control to installation; Bailey steam-flow-air-flow contactor; regulator and master controller—Engineer Co.; systems.

**Corrosion.** Korrosionsschaeden an 45-atue-Kesseln und ihre Beseitigung (Corrosion of 45-Atmos. Boilers and Their Avoidance), Zeigler. Mitteilungen der Vereinigung der Grosskesselbesitzer E. V., no. 32, May 31, 1931, pp. 121–127, 14 figs. Price 7 r. m. Experiences with corrosion of boiler at Merseburg Ammonia Works; cracks appearing in vertical-tube and in inclined-tube sectional boilers; results of tests.

**Design.** Der Engrohrkessel, ein neuzeitlicher Hochleistungskessel (Narrow-Tube Boiler, a Modern High-Capacity Boiler), K. D'Huart. Waerme, vol. 54, no. 27, July 4, 1931, pp. 515–519, 5 figs. Comparison of narrow-tube boiler with modern low, medium, and high-pressure boilers.

**Failures.** Ueber die Ursachen von Dampfkesselschaeden (Causes of Boiler Failures), O. Bauer. Mitteilungen der Vereinigung der Grosskesselbesitzer E. V., no. 32, May 31, 1931, pp. 89–100, 32 figs. Observations and experiences made over a number of years at State Materials Testing Institute, Berlin-Dahlem, concerning causes of defects and failures of boilers, based on which, rules for prevention of damages are suggested.

**Firing.** Conversion Factors, P. M. Biddison. Natural Gas, vol. 12, no. 8, Aug. 1931, pp. 6–7, 38, 45, and 66–68. Factors affecting cost of steam generation are discussed and advantages of gas firing enumerated.

Variable Cost of Steam Generation, P. M. Biddison. Oil and Gas Jl., vol. 30, no. 7, July 2, 1931, pp. 17 and 90–91. Factors affecting cost of steam generation; comparative analysis of hand firing with coal, stoker firing with coal, pulverized coal firing, oil firing, and natural gas firing; data submitted emphasize fallaciousness of generalization in comparison of steam costs with use of different types of fuel. Bibliography.

**High-Pressure.** Erfahrungen mit dem Schmidt-Hochdruckkessel (Experiences With Schmidt High-Pressure Boiler), O. H. Hartmann. Waerme, vol. 54, no. 27, July 4, 1931, pp. 503–511, 12 figs. Development of high-pressure steam; experiences with Schmidt high-pressure boiler with indirect heating; water circulation; behavior of primary boiler; boiler-feed problem, etc.

Hoechstdruck-Steilrohrkessel (Super-Pressure Vertical-Tube Boiler), W. Seeberger. Waerme, vol. 54, no. 27, July 4, 1931, pp. 497–502, 17 figs. Based on different examples, development of double-drum boiler is traced; author concludes that in boilers with maximum output and pressures, boiler part with natural water circulation is inferior to heating surfaces with forced circulation.

**Manufacture.** Bewertung des Schweissens in den fuer die Herstellung von Dampfkesseln gegebenen gesetzlichen Bestimmungen (Application of Welding to Boiler Manufacture Within Limits of Legal Code), K. Vigener. Waerme, vol. 54, no. 26, June 27, 1931, pp. 481–492, 18 figs. Necessity for regulations and their formation; code governing riveting and welding; examples of welds; testing methods for welded joints; regulations in other countries.

Uebersicht ueber die Schweissverfahren und die Pruefung der Schweissnaehte (Welding Processes and Testing of Welded Joints), K. L. Zeyen. Kruppsche Monatshefte, vol. 12, June 1931, pp. 121–123. Special consideration is given to welding in boiler making.

Attitude of Eleven Utilities Toward Welded Boilers. Elec. World, vol. 97, no. 21, May 23, 1931, pp. 955–957, 1 fig. N.E.L.A. prime movers committee has given welded boiler drums and tubes considerable study and A.S.M.E. boiler code committee is now engaged in formulating code that permits such construction; several utility executives and engineering or operating department heads were asked three questions treated later to ascertain possible trend of welded boiler acceptance and also what active cooperation might be expected from users in bringing about code acceptance.

**Safety Devices.** Protection Against the Bursting Gage Glass, E. M. Eliot. Nat. Safety News, vol. 24, no. 1, July 1931, p. 46, 2 figs. Requirements for gage glass protection and two types of commercial guards.

**Water-Tube.** Die juengsten Entwicklungsformen des Zweitrommelkessels (Latest Types of Two-Drum Boiler), O. Wirmer. Waerme, vol. 54, no. 27, July 4, 1931, pp. 512–514, 5 figs. With reference to article by author indexed in Engineering Index 1930, p. 207, from Nov. 30, 1929, issue of same journal, further development of two-drum vertical-tube boiler described therein is reported.

### BRASS

**Heat Treatment.** The Heat Treatment of Brass, H. M. St. John. Fuels and Furnaces, vol. 9, no. 7, July 1931, pp. 787–794 and 838, 5 figs. Principal question is one of grain size and interrelationship of grains; desirability of uniform grain size and relationship of temperature to grain structure; types of furnaces used in brass annealing; various annealing treatments used.

### BRASS FOUNDRY PRACTICE

**Cupola Melting.** Cupola Melting of Brass, T. Mauland. Metal Industry (N. Y.), vol. 29, no. 7, July 1931, pp. 304–305. Melting of brass in cupola when fuel used is of high fixed carbon content; alloys melted are 85–5–5–5 and 80–10–10 composition; castings produced consist largely of carburetors and bushings.

**Fundamentals.** The Fundamentals of Brass Foundry Practice, R. R. Clarke. Metal Industry (N. Y.), vol. 29, no. 7, July 1931, pp. 302–303. Basic laws which control melting and casting of metals and their application to foundry work.

# C

### CABLEWAYS

**Canary Islands.** Un funicular aereo para alcanzar la cima del Teide en Tenerife (Canarias), (Aerial Cableway for Reaching Summit of Teide Mountain in Teneriffe, Canary Islands), J. Ochoa y Benhumea. Anales de la Ascociacion de Ingenieros, vol. 10, no. 73, Jan. 1931, pp. 27–28. Résumé of costs of material and construction; estimate of annual receipts and operating expense, indicating probable profit of 40 per cent on invested capital. Concluded from paper indexed in Engineering Index 1930, p. 255, from issues of Aug. and Oct. 1930.

**Various Types.** Aerial Wire Ropeway, J. W. White. Junior Inst. Engrs.—Jl. and Rec. Trans., vol. 41, pt. 9, June 1931, pp. 399–421, 14 figs. Descriptions of various types and application of each.

### CADMIUM PLATING

**Theory and Practice.** Some Theoretical and Practical Aspects of Cadmium and Zinc Plating, S. Wernick. Metal Industry (Lond.), vol. 39, no. 1, July 3, 1931, pp. 14–16. Discussion including author's reply of paper previously indexed from issue of May 22, 1931.

### CAMS

**Design.** Zur Konstruktion von Kurvenscheiben bei Verarbeitungsmaschinen (Design of Cam for Machine Tools), K. A. Flocke. Forschungsheft, no. 345, June 1931, 20 pp., 14 supp. plates in envelope. General theory of cam curves; analysis of motion for different types of curves; oscillating curve drives.

### CASTINGS

**High Temperature.** Castings for High-Temperature Service, D. Hanson. Foundry Trade Jl., vol. 45, no. 777, July 9, 1931, pp. 19–20. Discussion of paper previously indexed from issue of June 4, 1931.

Some Considerations and Tests for Cast Materials for High-Temperature, High-Pressure Service, L. W. Spring. Foundry Trade Jl., vols. 44 and 45, nos. 773 and 776, June 11, 1931, pp 399–404, and July 2, pp. 7–10 and 12, 24 figs. Cast-iron brasses and bronzes and malleable iron are not dealt with at great length since, from high-temperature standpoint, steel is important material; specimens for accurate testing of cast steels; microstructural differences affecting creep; tests at high temperatures; strength vs. excess ductility; engineering application of creep data. American exchange paper before Inst. Brit. Foundrymen.

### CAST IRON

**Bismuth.** Effect of Adding Bismuth to Cast Iron, E. K. Smith and A. C. H. C. Aufderhaar. Iron Age, vol. 128, no. 2, July 9, 1931, pp. 96–100, 11 figs. Bismuth added to ladle and to crucible and electric-furnace melts of iron; addition to malleable iron and steel; bismuth acts primarily as deoxidizer in cast iron; bismuth-treated iron was found to have more life and fluidity than ordinary iron.

**Properties.** Relations entre les diverses propriétés mécaniques d'une part, les propriétés mécaniques et la structure d'autre part des fontes de moulage (Relations Between Different Mechanical Properties and Structure of Cast Irons), C. Baron. Revue Universelle des Mines, vol. 5, no. 2, July 15, 1931, pp. 33–35, 1 fig. Results of tests carried out on numerous different types of cast iron.

**Strength.** Ueber Wandstaerkenempfindliches Gusseisen (Cast Iron Sensitive to Wall Thickness), R. Mitsche. Giesserei, vol. 18, no. 27, July 3, 1931, pp. 537–539, 6 figs. Review of present knowledge of "wall-thickness sensitivity," explained in previous articles by author and others; qualitative test for determination of wall-thickness sensitivity is suggested and example given.

Ueber den Einfluss der Elemente Silizium, Phosphor, Aluminum Nickel und Chrom auf die Quasiisotropie und die Wandstaerkenempfindlichkeit von Gusseisen (Influence of Silicon Phosphorus, Aluminum, Nickel and Chromium on Quasi-Isotropy and Wall-Thickness Sensitivity of Cast Iron), E. Piwowarsky and E. Soehnchen. Giesserei, vol. 18, no. 27, July 3, 1931, pp. 533–537, 15 figs. Silicon and phosphorus increase and nickel reduces wall-thickness sensitivity; aluminum and chromium have neutral effect; is used to denote property of cast-iron alloy at different cooling speeds, to show variation in structure and hence in strength. See also Engineering Index 1930, p. 290.

**Welding.** Modern Cast Iron, A. B. Everest. Mech. World, vol. 89, no. 2321 and vol. 90, nos. 2322 and 2323, June 26, 1931, pp. 614–615, July 3, pp. 3–5, and July 10, pp. 34–35, 14 figs. Paper before Instn. Welding Engr., previously indexed from Machy. Market, Apr. 10 and 17, 1931, and Welding Jl., Mar. 1931.

### CHAIN DRIVE

**Roller.** Power Transmission by Roller Chains—I, W. A. Warrick. Power, vol. 74, no. 5, Aug. 4, 1931, pp. 152–154, 6 figs. Roller-chain and sprocket design has been so improved that applications include entire range of shaft speeds up to 4000 r.p.m.; principles of design and operation.

### CHROMIUM ALLOYS

**Corrosion.** Corrosion Resistance of Common Chromium Alloys. Metal Progress, vol. 20, no. 1, July 1931, p. 83. Table giving effect of acids, salts, organic substances and miscellaneous substances on chromium 12 to 14 per cent, carbon under 0.12 per cent; and chromium 18 per cent, nickel 8 per cent.

**Iron.** Chromium Iron Alloys, C. A. Scharschu. Metal Progress, vol. 20, no. 1, July 1931, pp. 59–63, 5 figs. Properties of various contents; application; machinability; corrosion resistance; heat treatment.

### CHROMIUM PLATING

**Durability.** How to Improve Durability of Chromium Plate, R. J. Piersol. Chem. and Met. Eng., vol. 38, no. 7, July 1931, pp. 386–389, 4 figs. Fundamental reason for lack of durability is fact that producer has not realized that designer must cooperate with authority in chromium field; use of brass as foundation metal has been chief cause of lack of durability of plumbing fixtures; automatic equipment should be introduced wherever possible; lack of durability has not been due primarily to poor workmanship or attempted economy but to imperfect understanding of influence of various factors on permanency of chrome fixtures.

### CHUCKS

**Advantages.** Why and How We Use Universal Chucks on Boring Machines, A. H. Keown. Indus. Woodworking, vol. 31, no. 10, July 1931, pp. 19–20, 2 figs. Advantages afforded by application of universal chucks on single-spindle boring machines.

### COAL

**Carbonization.** High-Low Temperature Carbonization, H. T. Wright. Gas Jl., vol. 195, no. 3554, July 1, 1931, pp. 32–34. Author maintains that there is no real controversy between high and low temperature carbonization; local conditions alone can decide which, or combination of both, should be employed.

Low Temperature Coal Distillation and Its Application to Modern Industrial Requirements, E. H. Smythe. Soc. Chem. Industry—Jl. (Chem. and Industry), vol. 50, no. 27, July 3, 1931, pp. 588–591. Effects of using raw coal; increasing use of crude oil; rational development of coal distillation; results obtainable; products.

**Combustion.** The Behavior of Solid Fuels During Oxidation—IV, B. Moore. Fuel, vol. 10, no. 7, July 1931, pp. 293–296, 7 figs. Influence of increasing oxygen temperature of ignition and combustion characteristics of and rate of heat loss from solid fuels.

The Influence of the Mineral Constituents on the Combustion of Solid Fuel, B. Moore and G. J. Wevell. Soc. Chem. Industry—Jl. (Trans. and Communications), vol. 50, no. 28, July 10, 1931, pp. 229T–242T, 30 figs. Effect of addition of inorganic compounds to fuel, free from ash, on reaction between fuel and oxygen.

Sur le mécanisme de la combustion du charbon pulvérisé dans les chambres des générateurs de vapeur (Mechanism of Combustion of Pulverized Coal in Boiler Furnaces), A. Grebel. Chaleur et Industrie, vol. 12, no. 133, May 1931, pp. 221–232, 7 figs. Principal factors in combustion; curves showing distribution of temperature in flame, probable changes of temperature and of linear velocity of combustion in relation to combustion heat.

**Processing.** The Action of Hydrogen on Coal, A. Crawford, F. A. Williams, J. G. King, and F. S. Sinnatt. Iron and Coal Trades Rev., vol. 123, no. 3305, July 3, 1931, p. 9; see also Colliery Guardian, vol. 142, no. 3678, June 26, 1931, pp. 2227–2229. Investigation of earlier stages; experimental work in which action was studied, in absence of complicating factors, such as vehicle and of catalysts other than ash of coal and materials of bomb; observations were made which appeared important both from point of view of their bearing on constitution of coal and of possible industrial application; improvement of coking properties of coal. Abstract of Fuel Research Board Tech. Paper no. 29.

### CONVEYORS

**Operation.** If Your Conveyors Are Gluttons, A. K. West. Brick and Clay Rec., vol. 79, no. 2, July 28 1931, pp. 76–78 and 80, 4 figs. Waste power in conveyor operation; details of economic mounting of gravity roller conveyor; other anti-frictionized conveyors.

**Packages.** Designing Conveyors for Storing Materials, C. K. Pevear. Mech. Handling, vol. 18, no. 7, July 1931, pp. 227–229. Ideal condition would be to eliminate manual handling at intermediate points between packing and shipping; equipment designed for Western Electric Co. for storage of packed finished materials. Before Materials Handling Meeting of Associated Industries, Boston.

**Speed Control.** Variable Speed Transmissions as Applied to Materials Handling Systems, D. W. Cled. Materials Handling and Distribution, vol. 6, no. 4, July 1931, pp. 47, 49–51, 3 figs. Necessity of infinitely flexible speed regulation on conveyors has two chief aspects; first is that it is highly desirable that output be under definite control; second lies in practical necessity of providing means to overcome operating irregularities; variable-speed transmissions are manufactured as standard in several hundred combinations to meet practically every conceivable condition.

### CUTTING TOOLS

**Grinding.** Etwas ueber Schliff und Schnitteinstellungen im Werkseugbau (Grinding and Cutting Practice in Tool Design), O. Lich. Maschinenkonstrukteur, vol. 64, no. 11, June 10, 1931 (supp.) pp. 121–122, 7 figs. Grinding methods for obtaining proper rake for milling cutters and thread cutting tools.

[See also TUNGSTEN CARBIDE.]

# D

### DIE CASTING

**Machine Elements.** Getting the Most Out of Die Castings, L. H. Morin. Iron Age, vol. 128, no. 6, Aug. 6, 1931, pp. 376–377 and 398. Examples suggestive of possibilities of die cast machine elements; die castings often permit desirable construction that would not be considered with more usual machined castings because of expense involved.

### DIESEL ENGINES

**Automotive.** Controversy Rages—Will the Auto Diesel Prevail, A. M. Wolf. Machine Design, vol. 3, no. 7, July 1931, pp. 21–25, 9 figs. Problems in design and operation of automotive Diesel engines; features of various makes including Waukesha, Coatalen, Packard and Cummins.

High-Speed Diesel With L-Head Developed by Waukesha Motors, M. Hofmann. Automotive Industries, vol. 65, no. 1, July 4, 1931, pp. 20–23, 7 figs. Design and performance data of 4-cylinder engine of 6¼ by 8 in. bore and stroke and developing 90 hp. at 950 r.p.m.; compression pressure between 425 and 450 lb. per sq. in.; explosion pressure near 650 lb. per sq. in., fuel consumption 0.48 lb. per hp-hr.

**Combustion Chambers.** Combustion Chambers of American High-Speed Diesels, E. J. Kates. Power, vol. 74, no. 3, July 21, 1931, pp. 92–93, 2 figs. Designs more clearly are grouped into a few general types; direct injection or single-chamber type; auxiliary air-chamber type; comparison of advantages and disadvantages of various types of combustion chambers.

**Fuels.** Refined Oils Necessary for Small High-Speed Diesel, A. L. Clayden. Automotive Industries, vol. 65, no. 3, July 18, 1931, p. 79. Research work of A.S.M.E. with particular regard to ignition point.

**Lubrication.** Diesel Engine Lubrication—VII, A. M. Tode. Mar. News, vol. 18, no. 2, July 1931, pp. 95, 102 and 103. Influence of construction on choice of lubricant.

**Marine, Buda-M.A.N.** The Buda-M.A.N. Marine Engine. Engineering, vol. 132, no. 3416, July 3, 1931, p. 27, 3 figs. partly on p. 26. In many of its features, such as employment of 4-stroke cycle in conjunction with airless injection, it follows design of M.A.N. engines made in Germany, but has constructive features peculiar to Buda engine; it is designed to run at 1000 r.p.m. and weighs from 25 to 35 lb. per hp.

**Maintenance and Repair.** Diesel Engine Upkeep—XIV, E. J. Kunze. Power Plant Eng., vol. 35, no. 14, July 15, 1931, pp. 753–755, 5 figs. Fuel transfer pump, storage and day tank maintenance; methods avoiding trouble; when and how to heat oil; tank cleaning and ventilation; alarms and indicators.

**Scavenging.** Scavenging Limitations of High-Speed Two-Cycle Diesels, J. W. Anderson. Power, vol. 74, no. 6, Aug. 11, 1931, pp. 205–206, 3 figs. Simple method of making comparisons with respect to scavenging problem; curves illustrating average port height for various crank-angle uncoverage.

**Vibrations.** Vibrations de Torsion dans les vilebrequins des moteurs Diesel (Torsional Vibrations in Crankshafts of Diesel Engines), V. A. Kjaer. Bul. Technique du Bureau Veritas, vol. 13, no. 5, May 1931, pp. 94–98, 9 figs. Advance calculation of factors controlling torsional vibration; importance in variation of natural frequency; experimental determination of damping coefficients; stopping and starting forces.

### DURALUMINUM

**Machining.** Machining Duralumin, J. Younger and W. R. Jenkinson. Am. Mach., vol. 75, no. 7, Aug. 13, 1931, pp. 269–271, 3 figs. Results of laboratory tests with different sizes and shapes of cutters.

# E

### ELECTRIC WELDING

**Arc.** Einfluss der Schweisstrombedingungen bei der elektrischen Lichtbogenschweissung von weichem Flusstahl) Influence of Welding-Current Requirements in Arc Welding of Low-Carbon Steel, N. Lefring. Stahl und Eisen, vol. 51, no. 27, July 2, 1931, pp. 859–860, 2 figs. Previously indexed from V.D.I. Zeit., Feb. 21, 1931.

"High Tensile Atomic Hydrogen Arc Welds in Alloy Steels," F. Ray. Am. Welding Soc.—Jl., vol. 41–45, 11 figs. Welding procedure in making Flexo Disk expansion joint which consists of steel bellows constructed of corrugated steel disks welded together at their inner and outer peripheries; properties of weld.

The Burke-Scott Electric Welder. Engineer, vol. 152, no. 3939, July 10, 1931, p. 48, 2 figs. Although primarily intended for arc welding, it may be used for other purposes that call for similar operating characteristics; machine may be regarded as one in which main pole parts are split into two parts, one part being shunt-wound and other series-wound.

### ELEVATORS

**Bucket.** Continuous Elevators for Bulk Materials and Piece Goods, W. H. Atherton. Mech. Handling, vol. 18, nos. 4, 5, 6 and 7, Apr. 1931, pp. 109–116, May, pp. 141–144, June, pp. 183–188, and July, pp. 207–211, 44 figs. Apr.: Moving elevators for handling packages and loose materials; types of package elevators; dynamics and types of bucket elevators; properties of Ley's black-heart malleable iron, of which elevator chain links are made. May: Vertical elevators; speed adjustment. June: Inclined elevators with spaced buckets; inclined coal elevators; curved and sludge-type elevators. July: Inclined continuous-bucket elevators; refuse elevators, etc.

### EMPLOYEES

**Training.** De Philips' Jongensnijverheidsschool (Philips' Trade School for Boys), R. Drucker. Ingenieur, vol. 46, no. 30, July 24, 1931, pp. W125–W131, 11 figs. Because of important expansion, requirements of Phillips' Lampworks, Eindhoven, for trained personnel could not be met by local trade school; started own trade school in 1928 by which, through four years practical theoretical system of education, boys are trained in seven different specialized branches adapted to requirements of company; school buildings; equipment and educational program are illustrated and outlined.

### ENGINEERING EDUCATION

**Cooperative Method.** Application of the Cooperative Method of Instruction to Engineering Schools and Polytechnic Institutes, D. C. Jackson, Jr. Am. Inst. Elec. Engrs.—Advance Paper, no. 117, for mtg. June 22–26, 1931, 6 pp. Because of variety of factors governing application of cooperative method, it is advisable to consider to what types of institutions of higher education cooperative idea is best adaptable; factors which should be considered before cooperative courses are introduced at any institution are size, geographical location, type of location, method of support, and organization of institution.

**Research.** The Place of the University in the Solution of Technical Problems, J. W. Cobb. Soc. Chem. Industry—Jl. (Chem. and Industry), vol. 50, no. 27, July 3, 1931, pp. 548–550. University laboratory will, as a rule, be more particularly able to deal with fundamentals of proposed new process than with its highly specialized detail; in long run, place of university in solution of technical problems is, more than anything else, that of agency for training in best manner possible those whose task it will be to aid in solution of these problems in different stages they present, and to give maximum usefulness to solutions when they are found.

# F

### FEEDWATER

**Treatment.** See BOILER FEEDWATER.

### FLOW OF FLUIDS

**Pipes.** Die praktische Anwendung der Reynolds' schen Zahl (Practical Application of Reynolds' Number), A. Koevesi. Roehrenindustrie, vol. 24, nos. 7 and 8, Mar. 26, 1931, pp. 73–76 and Apr. 9, pp. 88–89. Formulas for calculating flow resistance of various fluids in pipes; reference to principal research work.

La distribuzione dei vortici nelle condotte chiuse in regime turbolento e laminare (Distribution of Vortices in Closed Conduits at Turbulent or Laminary Regimen), B. Del Nunzio. Elettrotecnica, vol. 18, no. 14, May 15, 1931, pp. 320–324, 4 figs. Experimental study of frequency of formation of Benard-Karman vortices, using cut wires and Vecchiacchi-Guarnaschelli frequency meters, with oscillograph for checking determinations; methods of elimination of periodic phenomena in flow; bearing of this study on problems of heat convection.

Solving Dual Flow Problems by Graphical Analysis, G. K. Palsgrove. Water Works Eng., vol. 84, no. 14, July 15, 1931, pp. 1022 and 1025, 4 figs. Analysis of two typical problems to illustrate different methods of approach to graphical solution; many variations to problem. Before Am. Water Works Assn.

### FLUE DUST

**Removal.** Dust Elimination From Chimney Gases. Mech. World, vol. 90, no. 2323, July 10, 1931, pp. 30–32, 2 figs. As result of investigations by Davidson and Co., Sirocco Engineering Works, Belfast, during last six years, it is claimed that 70–95 per cent of dust in combustion gases can now be separated, in spite of fact that each ton of coal produces about 500,000 cu. ft. of gas; latest developments are represented by fans and dust collectors for new Dunston B. power station.

A New Form of Grit Catcher. Engineer, vol. 152, no. 3939, July 10, 1931, p. 45, 3 figs. Apparatus for separating grit and other solid matter from gases, designed by Pneumatic Conveyance and Extraction (1929), Ltd.; essential feature is scroll-shaped passage of triangular cross-section, through which dirty gases are drawn.

### FLUE GAS

**Analysis.** Verteilung des Carbon-Dioxide Gehaltes ueber den Querschnitt des letzten Kesselzuges (Distribution of Carbon-Dioxide Content Over Cross-Section of Last Boiler Flues), R. Orel. Archiv fuer Waermewirtschaft, vol. 12, no. 7, July 1931, p. 196, 2 figs. Investigation of boiler with coal and gas firing for purpose of comparing indications of flue-gas tester with actual mean values.

### FORGE-SHOP PRACTICE

**Procedure.** Etude du forgeage de quelques pièces (Study on Production of Some Forgings), L. Faure. Arts et Metiers, no. 129, June 1931,

pp. 193–198, 13 figs. Forging procedure and equipment used in making Forter valves.

**Steel.** Ghosts in Large Steel Forgings, J. F. Harper. Metal Progress, vol. 20, no. 1, July 1931, pp. 45–49, 5 figs. Physical tests of this class of material; possible explanations advanced as to formation of ghost lines; ghost or ghost line in forging is non-homogeneous streak of metal, in comparison to main mass; it may or may not contain cracks and non-metallic impurities.

### FOUNDRY PRACTICE

**Germany.** Deutsche Gesellschaft fuer Metallkunde. Metal Industry (Lond.), vol. 39, no. 2, July 10, 1931, pp. 31–32. Abstracts of some of papers read at meeting in Berlin; Does Separation Occur in Mixtures of Three Metals Completely Soluble in Each Other in Binary Mixtures? W. Guertler; Transportation of White Tin Into the Gray Modification (Tin Pest), G. Tammann; Determination and Removal of Gases and Oxides in Aluminum and Aluminum Alloys, R. Sterner-Rainer; Influence of Grain Size and Eutectic Composition on Corrosion of Lead, M. Werner; Electric Annealing of Copper and Brass, E. F. Russ.

**Methods.** The Development of Efficient Methods in the Foundry, E. M. Currie. Instn. Production Engrs.—Proc., vol. 10, no. 4, July 1931, pp. 121–129 and (discussion) 129–135. Résumé of history of founding; principles of foundry operations.

**Wage-Payment Plans.** Scientific Rate Setting Reduces Foundry Costs, T. M. Harrison. Iron Age, vol. 128, no. 1, July 2, 1931, pp. 10–11 and 52. Good wage-incentive system should reduce labor cost in average day-work foundry 25 per cent; why scientific rate setting on molding and core-making operations is important as means of reducing and controlling direct labor costs, as basis for standard cost finding, and as basis for exact estimating.

### FUELS

**Combustion.** Neue Kennlinien fuer den Verbrennungsvorgang bei festen, fluessigen und gasfoermigen Brennstoffen (New Characteristics for Combustion of Solid, Liquid and Gaseous Fuels), W. Otte. Archiv fuer Waermewirtschaft, vol. 12, no. 7, July 1931, pp. 197–200, 8 figs. Based on stoichiometric conditions of practical combustion process, for calculation of which seven basic equations are given, it is shown how relations between excess air, carbon-dioxide content of combustion gases and combustion carriers can be expressed in diagram for simple calculation of combustion phenomena; examples, accuracy of graphic method.

**Economy.** Fuel Economy in British General Industrial Practice With Particular Reference to the Work of the Federation of British Industries, G. W. Andrew. Soc. Chem. Industry—Jl. (Chem. and Industry), vol. 50, no. 27, July 3, 1931, pp. 571–576, 1 fig. Conclusions with regard to actual and prospective lines of development; illustration showing where wastage of heat frequently occurs in boilers.

# G

### GALVANIZING

**Hot.** Notes on Hot Dip Galvanizing, F. E. Sharp. Inspection, vol. 2, no. 3, July 1931, pp. xvii-xxii. Equipment of plant, materials and methods. Before Instn. Eng. Inspection.

**Zinc Bath.** Hartzinbildung und Eisensalze (Hard Zinc Formation in Iron Salt), K. Taussig. Stahl und Eisen, vol. 51, no. 28, July 9, 1931, pp. 885–886, 3 figs. Effect of iron salts on zinc bath; formation of hard zinc by iron chloride; precautionary measures.

Temperature and Purity of Zinc as Factors in the Production of Galvanizer's Dross, W. G. Imhoff. Iron and Steel Canada, vol. 14, no. 6, June 1931, pp. 93–94 and 107, 3 figs. Conclusions to be drawn from tests after heating pure zinc up to temperature of 1500 deg. fahr.

### GEARS

**Manufacture.** Equipment for Machining Steel Gear-Rings, I. F. Yeoman. Machy. (N. Y.), vol. 37, no. 12, Aug. 1931, pp. 953–956, 7 figs. Chucks and tools designed for production of steel rings or bands in which gear teeth are cut.

**Welded.** Canadian Firm Makes New Type of Welded Gear. Can. Machy., vol. 42, no. 14, July 9, 1931, pp. 30–31, 4 figs. All-steel spur gear developed by Hamilton Gear and Machine Co., Toronto, known as "Rolled-Weld;" welds are metallic, electrode type, made with Canadian General Electric arc-welding equipment.

**Worm.** Cutting Worm-Gears With Standard Spur-Gear Cutters, C. Dahlerup. Machy. (N. Y.), vol. 37, no. 12, Aug. 1931, pp. 927–928, 2 figs. Method of threading worms; cutting worm-wheels.

### GLIDERS

**Design.** The Development, Design and Construction of Gliders and Sailplanes, A. Lippisch. Roy. Aeronautical Soc.—Jl., vol. 35, no. 247, July 1931, pp. 532–570 and (discussion) 570–578, numerous figs. Theoretical and practical aspects of glider design as based on principles of soaring flight; constructional details and performance data; importance of motorless flight to development of aviation and advantages of all-wing principle.

### GRINDING

**Cylindrical.** Die Abhaengigkeit der Kosten des Rundschleifens von der Schleifscheibenbreite (Cost of Cylindrical Grinding as Depending of Width of Grinding Wheels), A. Schroeder. Maschinenbau, vol. 10, no. 12, June 18, 1931, pp. 426–427, 6 figs. Interpretation of tests based on article in "Grits and Grinds," bd. 21 (1930) No. 11; Norton Co., Worcester, Mass., U. S. A.

**Tests.** Versuche zur Ermittlung der Schnittflaechentemperatur beim Durchschleifen von Stahl (Test for Determining Surface Temperature in Cutting of Steel by Means of Grinding), S. Crisan. Maschinenkonstrukteur, vol. 64, no. 12, June 25, 1931, (supp.) pp. 133–135, 8 figs. Tests at Technical University of Dresden show that temperatures of 120 deg. cent. are not exceeded, in spite of high feeds.

# H

### HANGARS

**Wind Pressure.** An Investigation of Pressures and Vacua Produced on Structures by Wind, H. M. Sylvester. Rensselaer Polytechnic Inst.—Eng. and Science Series, no. 31, Jan. 1931, 53 pp., 40 figs. Theoretical and experimental study of magnitude and distribution of wind pressures on airship hangars to check erroneous assumptions made in design of roof structures particularly of those covering large free floor spaces; tests of laboratory models. Bibliography Memorandum of Wind Damage to Dirigible Hangar, Ernest H. Brownell.

### HELICOPTERS

**Developments.** Modern Developments in the Helicopter, R. N. Liptrot. Roy. Aeronautical Soc.—Jl., vol. 35, no. 247, July 1931, pp. 624–632. Review of typical helicopter designs including Oemichen, Pescara, Berliner, Karman Petroszy, Moineau, Isacco Helicogyro, Curtiss Bleecker, D'Ascanio, and Asboth; calculation of sustentation.

### HYDROELECTRIC POWER DEVELOPMENTS

**India.** Upper Ganges Hydro-Electric Scheme. Elec. Times, vol. 80, no. 2071, July 2, 1931, pp. 3–7, 6 figs. Electrification scheme generates power from falls on upper Ganges canal and serves agricultural community covering 10,000 sq. mi.

**New England.** Fifteen-Mile Falls Power Plant Eng., vol. 35, no. 13, July 1, 1931, pp. 692–696, 8 figs. New England Power Association's Connecticut River project includes lower development providing 156,000-kva., McIndoes Falls 13,200-kva. plant with two Kaplan and two fixed-blade propeller runners and first 220-kv. transmission lines in New England; intake structure; electrical equipment; McIndoes Falls development.

**Uruguay.** Utilizacion hidroelectrica del Salto Grande del Uruguay (Hydroelectric Development of Big Falls of Uruguay River), A. Ludin. Revista de Ingenieria, vol. 25, no. 1, Jan. 1931, pp. 4–27, 5 figs. Power yielded; cost of construction; annual operating cost; cost of auxiliary thermal electric power; outline of principal factors to be considered in drawing up new project; advisibility of joint political agreement made between Argentina, Brazil, and Uruguay for complete utilization of their hydroelectric power.

### HYDROELECTRIC POWER PLANTS

**Automatic.** Das Elektrizitaetswerk Thorenberg von 1885 bis 1931 (Thorenberg Electric Plant From 1885 to 1931), H. Mueller. Assn. Suisse des Electricien—Bul., vol. 22, no. 12, June 12, 1931, pp. 288–295, 8 figs. First hydroelectric plant to employ full a.c. operation; was private enterprise from erection in 1886 until 1897 for supply of Lucerne; in 1930, was remodeled and automatized and now employs 1 three-phase hydroelectric turbine of 1000 kva., 3700 volt, 214 r.p.m., and 50 cycles; power is transmitted 2.5 km. to steel plant in Emmenweid; savings obtained through automatic operation amounts to 9000 francs annually.

**Brazil.** A inauguracao da Usina Hydro-electrica de Chaminé, no. Paraná (Starting of Chamina Hydro-electric Plant in Parana). Revista Brasileira de Engenharia, vol. 21, no. 4, Apr. 1931, pp. 113–116, 4 figs. Plant of Companhia Forca e Luz do Parano, 55 km. from Curityba, began operating Apr. 15, 1931; participation of Electric Bond and Share Co. of New York; capacity 11,000 hp. can be doubled with additional equipment; two turbines, each with 5000 kva. generators; current at 6600 volts, stepped to 266,000 v. for transmission; substation at Curityba reduces to 13,200 volts and later to 220 or 110 volts for distribution.

**Maintenance and Repair.** Organizing for Plant Operation and Maintenance, A. S. Robertson. Hydro-Elec. Power Commission of Ontario—Bul., vol. 18, no. 6, June 1931, pp. 190–200, 5 figs. Value of service shop; organization chart and proposed maintenance schedule and actual record in days for Queenston generating station; duties of operating staff; preparing maintenance schedules; reducing time and costs, example of detailed job for rewinding a large generator; assembly of several individual job schedule sheets covering major repair on large unit.

Organizing Hydro-Electric Inspection and Maintenance, J. E. Housley. Power, vol. 74, no. 2, July 14, 1931, pp. 54–55, 3 figs. How inspection and maintenance organization was developed to take care of system that in few years grew to capacity of 286,000 hp. in three plants several miles apart.

Maintenance Methods That Reduce Hydro-Plant Operating Costs, J. E. Housley. Power, vol. 74, no. 4, July 28, 1931, pp. 124–126, 3 figs. Outline of inspection and maintenance procedure of turbines and governors in three large hydro-electric plants on same system, where high degree of reliability is imperative; illustrated inspection reports.

**Pumped Storage.** Usina Hidraulica Acumuladora en el Cerro de Montevideo (Hydroelectric Accumulator Plant on Montevideo Mountain), A. Ludin. Revista de Ingenieria, vol. 25, no. 4, Apr. 1931, pp. 135–162, 13 figs., partly on supp plate. In view of projected hydroelectric utilization of Rio Negro, with city of Montevideo as principal consumer of power generated, storage of energy to meet peak load is desirable; preliminary study for project of reservoir on Montevideo mountain with auxiliary generating station, if this accumulated station is not built, Rio Negro power station and transmission line will have to have greater capacity to meet maximum peak load.

**United States.** Outdoor Features Simplify Osage River Hydro Design. Elec. World, vol 97, no. 26, June 27, 1931, pp. 1212–1214, 4 figs. Structural simplicity has been obtained to striking degree in new hydroelectric development of Union Electric Light & Power Co. on Osage River near Bagnell, Mo., by utilizing outdoor type of station and generating unit design, paralleling generators on low-tension bus only and omitting high-tension buses; ultimately this plant will contain eight units aggregating 220,000 kva.

Saluda Development Is Rich in New Engineering Features, A. P. Campbell, J. P. Garvin, A. W. Reed, and N. D. Urquhart. Elec. Jl., vol. 28, no. 5, May 1931, pp. 265–268, 7 figs. Plant has added additional 130,000 kw. to generating capacity in South Carolina, besides having created second largest artificial lake in United States, and largest earth filled power dam in world, built for Lexington Waterpower Co. on Saluda River near Columbia, S. C., it will have ultimate capacity of 195,000 kw., at present four 32,500 kw. generators are installed.

# I

### INDUSTRIAL MANAGEMENT

**Analysis.** Management A B C's—5, H. Diemer. Factory and Indus. Mgmt., vol. 82, no. 2, Aug. 1931, pp. 207–208 and 219, 4 figs. Routing and process analysis.

**Budget Control.** Budgetcontrole haar algemeen karakter en bijzondere beteekenis voor de conjunctuur-politiek in het bedrijf (Budget Control, Its General Character With Special Regard of Its Significance for Business Policy in Operating Management), A. Mey. Ingenieur, vol. 46, no. 29, July 17, 1931, pp. T61–T70. Operating cost estimate as combination of com-

ponent valuations, composition, and purpose of estimates, budget in operating management, etc.

**Small Plants.** Small Plant Successes—Just Good Management—VIII, A. H. Mogensen. Factory and Indus. Mgmt., vol. 82, no. 2, Aug. 1931, pp. 209–211, 4 figs. How Hygrade Lamp Co. has developed to concern with $3,000,000 assets from capital of $3500 in 30 years.

### INTERNAL-COMBUSTION ENGINES

**Valves.** Die Umlaufventilsteuerung Baer (Rotary Valve Control "Baer"), J. Rozendaal. Automobiltechnische Zeit., vol. 34, no. 18, June 30, 1931, pp. 436–438, 4 figs. Design and operating principles of rotary valve consisting of cast-iron tube provided with channels for intake and exhaust gas; sketches illustrate method of preventing gas leakage and lubrication.

**Vibrations.** Reducing Torsional Vibration by Damping Devices, J. Ormondroyd. Machine Design, vol. 3, no. 7, July 1931, pp. 33–36, 5 figs. Several devices for purpose of eliminating torsional vibration, including Lanchester damper, are considered.

[See also AIRPLANE ENGINES; DIESEL ENGINES.]

### IRON AND STEEL

**Corrosion.** Corrosion: What It Is, W. S. Johnston. Power, vol. 74, no. 3, July 21, 1931, pp. 87–89. First of three articles dealing with corrosion of iron and steel, with special reference to power-plant equipment, case where water is vehicle, or catalyst, and included oxygen is agent directly responsible for corrosion; pitting found beneath rust; effect of sulphurous acid; depolarization removes protecting film; removal of mill scale reduces pitting.

### IRON-NICKEL ALLOYS

**Tests.** Beispiel eines instabilen Zustandes in Legierungen, der sich auch bei 1000 deg. nicht zur Reaktion bringen laesst (Fe-Ni-Le-gierungen) (Example of Unstable Condition in Alloys, Which Cannot Be Brought to Reaction at Temperature of 1000 Deg.), L. Anastasiadis and W. Guertler. Zeit. fuer Metallkunde, vol. 23, no. 6, June 1931, pp. 189–190, 5 figs. Diagram of state of iron-nickel system; results of tests by means of electric resistance measurement.

# L

### LOCOMOTIVE BOILERS

**Corrosion.** Ursache und Deutung von Korrosionsschaeden an Lokomotivekesseln (Causes and Significance of Locomotive Boiler Corrosion), G. Rittler. Verkehrstechnik, no. 21, May 22, 1931, pp. 257–260, 9 figs. Different kinds of corrosion, their causes and typical examples; effect of aggressive waters.

The Corrosion of Locomotive Boilers, L. Brearley and W. S. Macartney. Commonwealth Engr., vol. 18, no. 11, June 1, 1931, pp. 395–398, 2 figs. Result of experiment indicates two causes of corrosion (1) solubility of iron and steel in water, and (2) presence of oxygen in water; remedies suggested.

### LOCOMOTIVES

**Articulated.** New Garratt Locomotives for the Kenya and Uganda Railway. Ry. Gaz., vol. 54, no. 23, June 5, 1931, pp. 829–830, 2 figs. Features of 4-8-2 plus 2-8-4 locomotives built by North British Locomotive Co., for heavy work on meter gage; cylinder 16½ by 22 in., coupled wheels 3 ft. 7 in.; total engine wheelbase 72 ft., boiler pressure 170 lb. per sq. in.; tractive effort of 85 per cent boiler pressure 40,255 lb.; total weight in working order 137 tons.

**Design.** Locomotive Design and Construction. Ry. Jl., vol. 37, no. 7, July 1931, pp. 20–24, 11 figs. Counterbalancing of locomotives; pressure for mounting driving, trailing and engine-truck axles and crankpins; flange and tread contour for engine truck, driving and trailer wheels; eccentric cranks; unification of screw threads. Before Am. Ry. Assn.

**Diesel.** The Diesel Compressed Air Locomotive. Ry. Engr., vol. 52, no. 618, July 1931, pp. 276–279, 4 figs. Trend of design and comparisons between different systems; number of stages required in air compressor depends upon maximum pressure demanded; efficiency of system; work ratio; compressed-air transmission in practice; German compressed-air locomotive discussed.

**Superheater.** Transformation des locomotives Pacific compound à grande vitesse série 3501 à 3589, de la Compagnie d'Orléans (Revamping of High-Speed Pacific Compound Locomotives, Series 3501 and 3589 of Compagnie d'Orléans), A. Chapelon. Revue Générale des Chemins der Fer, vol. 50, no. 1, July 1931, pp. 18–67, 23 figs. Economics obtained by modifications of steam lines, increase in superheating, and application of distributing valves.

### LUBRICANTS

**Carbon Residue.** The Carbonization of Lubricating Oils, H. N. Bassett. Soc. Chem. Industry—Jl. (Chem. and Industry), vol. 50, no. 26, June 26, 1931, pp. 527–529. Investigation of why some oils give more carbon than others, and what leads to physical differences in deposits; testing methods may be divided into three groups, namely, evaporation (volatility), coking, and oxidation tests; it still remains for test to be furnished which will give really satisfactory basis for estimation of residue which may be expected from lubricating oils when oxidized under conditions existent in automobile engine.

**Properties.** Ueber Schmieroele aus paraffinfreien und paraffinhaltigen Rohoelen (Lubricating Oils From Crudes With and Without Paraffin), H. Ordelt. Petroleum, vol. 27, no. 28, July 8, 1931 (supp.) pp. 3–9, 5 figs. Temperature-viscosity curves for paraffin-ceresin varieties; it is shown that paraffin oils need not be classified in general as poor oils with regard to their lubricating value.

**Testing.** Tests on Lubricants for Turbine and Engine Service, F. L. Grav. Power, vol. 74, no. 2, July 14, 1931, p. 64. Paper before Assn. Iron and Steel Elec. Engrs., previously indexed from Iron and Steel Engr., June 1931.

Laboratory Determination of Lubricating Ability. Lubrication, vol. 17, no. 6, July-Aug. 1931, pp. 61–66, 2 figs. Gist of more prominent methods; Navy work factor method; significance of tests; precipitation tests; acidity as determined by neutralization; carbon residue.

**Viscosity.** Sobre La Viscosidad Absoluta y Metodo de Medicion de La Misma (Absolute Viscosity and Method of Measuring It), H. Strasser. Boletin de Informaciones Petroliferas Yacimientos E Industrias, vol. 8, no. 80, Apr. 1931, 12 pp., between 247–261. General remarks on viscosity of liquids, and specific application to petroleum lubricants; empirical law of Poiseuille for determining viscosity of liquid movement in capillary tube; apparatus designed by Dr. Bles, used for measuring absolute viscosity of oil; test results on lubricants manufactured in United States.

# M

### MACHINE SHOPS

**Production Planning.** I. Prix de revient du travail effectué sur machine-outil. II. Les marteaux pneumatiques et leurs applications. III. Les caractéristiques d'un bon montage d'usinage (Cost Price of Work Done on Machine Tools. II. Pneumatic Hammers and Their Application. III. Characteristics of Efficient Setup for Machining), L. Lenouvel. Science et Industrie, vol. 15, no. 209, June 1931, pp. 304–307, 5 figs.

### MACHINE TOOLS

**Design.** Modern Tendencies in Machine Tools. Instn. Production Engrs.—Jl., vol. 10, no. 4, July 1931, pp. 136–144 and (discussion) 144–150. Grouping of controls for convenience of operator; provision of quick power traverse motions; provision of automatic stops and gaging devices; quick change gear boxes; central lubrication system; unit construction for ease in manufacture and repair; elimination of overhead gear; provision of guards and safety devices.

Werkzeugmaschinen mit hoechsten Drehzahlen (Machine Tools for Highest Speed), E. Preger. V.D.I. Zeit., vol. 75, no. 28, July 11, 1931, pp. 893–898, 26 figs. Design and performance of representative German makes built especially for use of Widia and diamond cutting tools; merits of different types of bearings with regard to accuracy and load capacity.

Designing to Overcome Centrifugal Forces, S. C. Martin. Machine Design, vol. 3, no. 7, July 1931, pp. 43–45, 4 figs. Methods and formulas of determining principal stresses due to centrifugal forces; design of centrifugal baskets for driers, separators, and similar machinery are considered.

**Replacement.** Planned Buying of Machine Tools, With Adequate Sinking Fund Provisions, Will Reduce Costs, J. Geschelin. Automotive Industries, vol. 65, no. 3, July 18, 1931, pp. 80–83, and 96, 2 figs. Answers to factors entering into selection and replacement of equipment; Warner & Swasey financial statement used in demonstrating service value of new machine; card record developed by Union Special Machine Co. to evaluate existing installations for replacement.

**Testing.** Genauigkeitspruefung von Werkzeugmaschinen durch Energiemessung (Testing of Accuracy of Machine Tools by Means of Energy Measurements), G. Schumacher. Maschinenbau, vol. 10, nos. 12 and 13, June 18, 1931, pp. 415–418 and July 2, pp. 446–449, 12 figs. Advantages of accuracy tests by means of recording watt-meters; calculation of multi-drum brakes applied to multi-spindle screw machine; evaluation of records for optimum performance of screw machines.

### MATERIALS HANDLING

**Economics.** Practical Applications of the A.S.M.E. Formula—I, C. B. Crockett. Matls. Handling and Distribution, vol. 6, no. 4, July 1931, pp. 23–24, 1 fig. Example given to show simplicity of formula used for figuring savings effected by materials-handling installations.

Applying Handling Equipment and Determining Its Earnings, W. L. Hartley. Indus. Transmission and Conveying, vol. 38, no. 6, June 1931, pp. 7–8 and 15–16, 2 figs. Handling of materials cost industry three billion dollars yearly; cost per plant varies from 5 to 80 per cent of total payroll; savings effected by handling equipment varying from $1000 to $47,000 in 40 plants surveyed; these savings or earnings repaid cost of equipment in 32 plants surveyed, in 19.7 months, return of 60 per cent on investment. Before Grand Rapids Engrs.' Club.

**Equipment.** What Users Should Know About Materials Handling, E. J. Tournier. Factory and Indus. Mgmt., vol. 82, no. 2, Aug. 1931, pp. 173–175, 5 figs. Type of equipment to use, where to use it and performance of each type.

Enquête sur l'état actuel de la technique des Appareils de Levage et de Manutention mécanique (Enquiry on the Actual Situation of the Technique of Lifting Apparatus and Mechanical Handling Gear), M. Pelou. Science et Industrie, vol. 15, no. 209, June 1931, pp. 291–303, 29 figs. Diverse types of traveling cranes for normal gage railroads and for wide gage tracks; first of these are grouped into two categories, i.e., those which are only exceptionally displaced on railroad tracks and those which travel frequently.

**For Plant Storage.** Cutting Delivery Time From Ten to Two Days, R. Birkin. Matls. Handling and Distribution, vol. 6, no. 4, July 1931, pp. 42–44, 3 figs. Changing stock to standard sizes and installing handling equipment for plant storage.

How Chesebro, Whitman Company Simplified Storage and Delivery, G. G. Wheat. Matls. Handling and Distribution, vol. 6, no. 4, July 1931, pp. 19–22 and 45, 12 figs. Method and equipment used by Chesebro, Whitman Co. to handle steel scaffolding in warehouse.

**Methods.** Internal Transportation of Goods and Materials, T. E. Dimbleby. Mech. Handling, vol. 18, no. 7, July 1931, pp. 217–220. Choosing transport system; operating costs; mobile and overhead cranes; gravity roller conveyors; elevating-platform trucks; modern transport methods. Before Ipswich Engineering Society.

### METALS

**Cold Rolling.** The Design of Rolls for Cold Roll Forming Machines—II, D. A. Johnston. Metal Stampings, vol. 4, no. 7, July 1931, pp. 571–572 and 606–607. Additional phases of mathematical procedure employed in design of rolls for cold roll forming machines, together with chart.

**Fatigue.** Crystallographic Investigation of Some Mechanical Properties of Metals, Y. Kidani. Tokyo Imperial Univ., Faculty Eng.—Jl., vol. 19, no. 7, May 1931, pp. 177–190, 14 figs., 4 supp. plates. Crystallographical study of fatigue of metals under alternating torsion; testing internal friction of fatigue specimens; microphotographs illustrate the structure of steel and copper specimens.

**Non-Ferrous.** Heat Treating and Annealing Non-Ferrous Metals, A. H. Vaughan. Fuels and Furnaces, vol. 9, no. 8, Aug. 1931, pp. 939–941, 1 fig. Use of various types of electric furnaces in the heat treatment of non-ferrous metals and alloys.

**Spraying.** Das Metallspritzverfahren als Schutz gegen Korrosion (Metal-Spray Process as Protection Against Corrosion), H. Pauschardt. Korrosion und Metallschutz, vol. 7, no. 6, June 1931, pp. 139–145 and (discussion) 145. Investigations carried out in Kiel Municipal laboratory to determine corrosion resistance, especially in seawater, of plates treated according to metal-spray process; sprayed results of tests on plates sprayed with cadmium, zinc and bakelite, zinc and mercury, and some other metals; aluminum plates.